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Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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JOURNAL
OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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A GIRDLE ROUND ABOUT THE EARTH

IT IS NOW TWO YEARS SINCE THE FIRST CONVERSATION took place by cable between Europe and North America. The engineers, on both sides of the Atlantic, who planned and constructed that cable have every reason to be pleased with the way in which the public have taken advantage of the high-quality telephone circuits in it. Traffic is not only greater than was forecast; it is steadily increasing. To give an on-demand service has already become a problem at those times of the day when business hours in London, New York, and Montreal overlap, even though radio services may be used to supplement the cable.

A second cable system across the North Atlantic is planned for 1959. Technically it will be identical with that completed in 1956. Between Nova Scotia and Newfoundland there will be a single cable with British-made repeaters amplifying speech signals passing in both directions. From Newfoundland eastwards there will be twin cables, one for each direction of transmission. They will be equipped with the present American design of unidirectional repeater. These cables will land on the west coast of France. The United Kingdom will not participate in ownership, although some of the cable will be manufactured here and the cable laying will be done by the Post Office Cable Ship *Monarch*.

As most readers of the *Journal* know, Cable and Wireless Limited and the Canadian Overseas Telecommunication Corporation plan to lay the third transatlantic cable system in 1961. A single cable will, for the first time, carry speech signals in both directions across the long, deep-water section between Europe and North America. This will mark a major step forward in submarine cable technology.

To achieve it, the Post Office, Cable and Wireless, and the Canadian Corporation are pooling all their technical resources. A new type of high-performance thermionic valve will be used in about 90 both-way repeaters between Scotland and Newfoundland, the underwater placing of which will be facilitated by the use of a new type of deep-sea cable. The capacity of this new Canadian cable—measured in terms of 4kc/s channels—will be 60 circuits.

There are other developments in hand which will increase the capacity of the existing cable, and later of new cables as required. First is the projected use of speech channels spaced only 3kc/s apart instead of the conventional 4kc/s—giving a 33% increase in the number of channels possible. It has been found possible to do this with very little loss in the quality of the conversation (actually only about 300c/s will be lost from the effective width of the channel) as a result of a notable British achievement in the design and construction of channel filter equipment. There is also the development in America of high-speed channel-switching equipment known as TASI (Time Assignment Speech Interpolation). This will take advantage of the intervals when people are listening by assigning the channels left idle to other talkers. By this means it will be possible to double the number of conversations handled by a large group of circuits.

But engineers are beginning to look to waters other than the North Atlantic. Radio may suffice for a time for telephony across some of these other waters, but on many world routes radio cannot satisfy even immediate needs in terms of quality and regularity of service. Technical development has reached a stage when the engineering planning of a world-wide network of telephone cables could proceed.* Economically the prospects are not as attractive as those across the North Atlantic, where the large amount of traffic and the comparatively short distance combine to make the route profitable.

Nevertheless, the American Telephone and Telegraph

* Since this Foreword was written, proposals for a round-the-world cable scheme have been officially announced. A description of this project appears on p. 600.

Company have already laid a cable part-way across the Pacific, and the future connection of Australia with New Zealand might be a link in a new cable system in the Western Hemisphere. The picture must be particularly attractive to countries in a widely scattered Commonwealth which has hitherto played a leading part in providing world communication.

But before the world network has spread very far we may expect to see a television cable connecting Europe and North America. Much work has still to be done to mature the transistor art to the level of the long-life thermionic valve, but a cable with transistor amplifiers at intervals of no more than about 10 miles and capable of transmitting a full television bandwidth appears as a definite long-term possibility. Transatlantic television may not have to wait for this, because the television engineer is coming to meet the cable engineer in reducing his bandwidth requirements for topical pictures.

Admiralty Reorganization

THE reorganization of the Admiralty's materials departments under the Controller of the Navy, announced last December, was completed on the 1st October this year with the setting up of the new ship department. The work now falls within four large departments and a small group of scientific departments.

The four large departments—ships, weapons, aircraft, and dockyard and maintenance—are each administered by a director general, and the responsibility for the co-ordination and direction of work now lies with them instead of, as formerly, with the Controller. In addition, the Director General, Ships, is principal technical adviser to the Board of Admiralty. The work within each department is allocated to a number of 'professional' divisions, each division being headed by a director. Thus, under the new scheme, electrical engineering is a division of the ship department, radar is part of the radio division of the weapons department, and air radio is an independent section of the aircraft department.

In the ship department, staff of different divisions are combined into 'ship groups', studying problems of particular classes of ships, and specialist groups, carrying out development work on problems of common interest to all ships, such as stability, lighting, cables, etc. Applied research will continue to be carried out at the various scientific establishments, and their superintendents are responsible for the work of the various establishments to the Director General, Ships, through the directors of the appropriate professional divisions. Since the ship department now contains divisions specifically concerned with the installation of machinery and equipment, the directors of the marine and electrical engineering divisions will be responsible for the production (as opposed to the installation) of main and auxiliary machinery and electrical equipment and for the associated headquarters sections and overseeing services.

The scientific departments are headed by the Chief of the Royal Naval Scientific Service and are broadly responsible for basic research and development, the provision of scientific staff and advice to the materials departments, and the planning and co-ordination of Admiralty research programmes.

This reorganization is said to be a necessary and logical step, as the problems arising in the design of installations in ships have become increasingly interconnected with the problems of hull structure. It is hoped that the success of the scheme will be shown in closer co-ordination and co-operation between departments, and also, by delegating the work of the Controller to the four directors general, that the Controller will be able to concentrate more on general policy, major projects in hand, and the effects of change in naval-staff requirements on H.M. ships, naval aircraft, and their weapons.

Nuclear Power Station in Suffolk

THE Central Electricity Generating Board have applied to the Minister of Power and to the local planning authority for consent to develop a site at Sizewell, Suffolk, for their sixth nuclear power station. The proposed station will have an output capacity of about 650 MW and will be connected to the Grid by transmission lines westward. The site is on the coast, with deep water available close inshore for cooling requirements.

Nuclear power stations are now being built by the Board at Berkeley, Gloucestershire (275 MW), at Bradwell, Essex (300 MW), and at Hinkley Point, Somerset (500 MW). Work is being started at Trawsfynydd, Merionethshire (500 MW), and application has been made for consent to develop a site at Dungeness.

World Data Centre

A WORLD data centre for rockets and satellites is now operating at the Radio Research Station, Slough, and is the last of three such centres to be established under the International Geophysical Year arrangements for centralizing this type of information. The two others are in Moscow and Washington. In most I.G.Y.-subject fields there are three data centres, and there is already one for the ionosphere at the Radio Research Station.

Information from British investigations and observations, as carried out for instance at Jodrell Bank, the Cavendish Laboratory and the Radio Research Station itself, will be collected by the Slough data centre and exchanged with the centres in the United States and the Soviet Union. All data will be available for inspection and use by workers in the respective fields under arrangements which apply to all I.G.Y. world data centres.

621.382 THE JUNCTION TRANSISTOR AND ITS APPLICATION

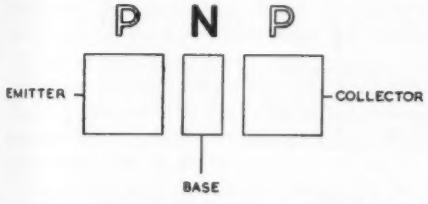
The junction transistor—How does it work? How is it used? An attempt has been made to answer both questions in this article, which describes the theoretical model of the transistor, shows how it is biased for operation, and finally indicates briefly how it it used both in industry and in the home. The author is Chief Semiconductor Applications Engineer of the Mullard Radio Valve Co. Ltd.

E. WOLFENDALE, B.SC., ASSOCIATE MEMBER

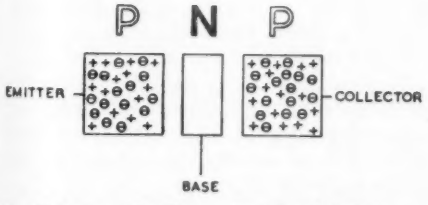
TRANSISTORS have now established their place in the field of electrical engineering, and today, although many different types are manufactured with widely differing properties, all are based on one theoretical model, that of a junction transistor. In this article I will describe this theoretical model and show how the wide variety of transistors which have been developed from it are used both in industry and in the home.

The theoretical model

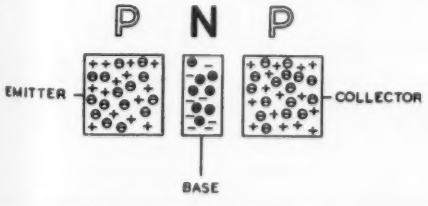
The transistor is made from a single crystal of a semiconductor, which is a material intermediate between a conductor and an insulator. For the purpose of examining the theoretical model we will consider the semiconductor germanium, as it is from this that the majority of present-day transistors are made. The model comprises three parts: the emitter, the base, and the collector, as shown in Fig. 1, all three being made of pure germanium. This contains very few free carriers (electrons or positive carriers), and for simplicity we will neglect these at present.



1 *Theoretical model of transistor, showing its three basic parts*



2 *Emitter and collector doped with indium*



3 *Base doped with antimony*

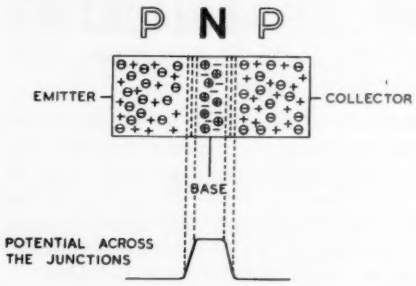
A small quantity of indium is introduced into the emitter and collector. The indium atoms enter the germanium lattice, and each forms an indium ion in the lattice and releases a positive free carrier. The positive free carriers are called 'holes' and are free to move around within the germanium, while the negative indium ions are fixed and are shown ringed in Fig. 2.

A small quantity of antimony is introduced into the base. Each antimony atom entering the germanium lattice forms a positive ión and releases a negative free carrier called an 'electron'. Electrons, like the holes, are free to move around within the germanium lattice (see Fig. 3).

If we now bring these three pieces together, as shown in Fig. 4, positive holes will leave the emitter and collector and will migrate into the base, and negative electrons will leave the base and migrate into the emitter and collector. Positive holes leaving the emitter and collector and entering the base will combine with the negative electrons there, and negative electrons leaving the base will combine with positive holes in either the emitter or collector.

As the base loses electrons and the emitter and collector lose positive holes, the base becomes positive with respect to both emitter and collector. This process of migration of carriers across the two junctions will continue until the potential differences between base and emitter, and base and collector, are sufficient to prevent any further migration of carriers across the junctions. In

this way fields are established across the two junctions so as to prevent the migration of free carriers, and we reach an equilibrium condition, as shown by the potential diagram in Fig. 4. The two regions at the junction are known as depletion layers, because they are depleted of free carriers.



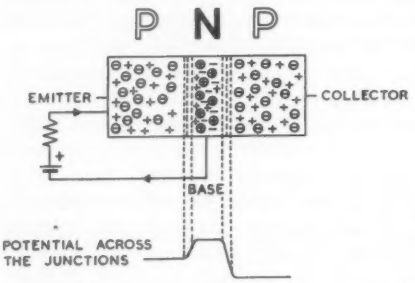
4 *Potential distribution resulting from the three parts joined together*

Using the transistor

To use the transistor we disturb the equilibrium picture, and first we will bias the emitter positively, as shown in Fig. 5. The battery potential is such that it will reduce the barrier potential across the emitter junction. Free carriers can now recross the emitter junction, and holes will cross from the emitter into the base and electrons from the base into the emitter. In a practical transistor the concentration of indium in the emitter and collector is made very much greater than the concentration of antimony in the base, resulting in a much higher concentration of holes in the emitter and collector than there are electrons in the base. This means that, now we have disturbed the equilibrium condition at the emitter, most of the current flow is caused by holes passing from the emitter into the base, and very few electrons flow back from the base into the emitter. For the purpose of the example we will consider that virtually all the current flow from the emitter into the base is by positive holes. These positive holes will exist in the base region for some time and then recombine with the electrons there. The time that they can exist in the base is known as the 'lifetime' of the base material. Electrons lost in the base by recombination with holes are, of course, made up from the negative of the battery. Current will therefore flow from the positive of the battery to the emitter, holes across the emitter junction to the base, and negative electrons from the negative of the battery to make up recombination in the base.

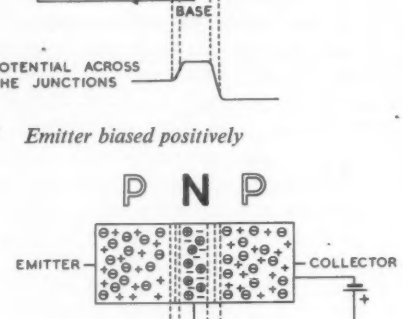
We will now remove the potential from the emitter and apply an opposite potential to the collector, as shown in Fig. 6. This additional potential in the collector increases that across the base-collector junction and further increases the potential which was preventing the flow of carriers across that junction. There is therefore no current flow in the collector. In practice a small current does flow, owing to thermal generation of carriers around the collector junction, but at present we may neglect this.

If we now re-bias the emitter as shown in Fig. 7, holes will once again cross the emitter junction into the base. These holes then exist for some time before they recombine with electrons, and in practice the base of the transistor is made so narrow that before these holes have a chance to recombine the majority of them reach the field at the collector junction. This field is in such a direction as to sweep the holes from the base into the collector. The current flow is now therefore from the emitter, through the base, to the collector, and back by the external batteries to the emitter, and only a very small current flows in the base due to a small number of holes combining with electrons in their passage across the base.



5 *Emitter biased positively*

6 *Collector biased negatively*

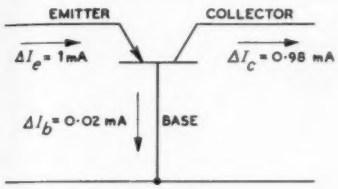


7 *Emitter and collector biased so that current flows from emitter, through base, to collector*

It is this current flow from the emitter through the base into the collector which gives us the transistor action and enables us to use the transistor as an amplifier.

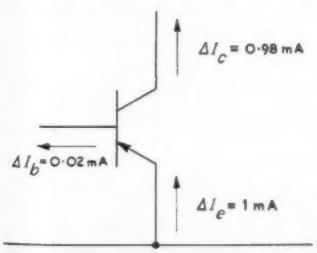
Amplification

To see how the transistor action gives us amplification we examine Fig. 8, which shows the symbol used for the transistor. As the main current flow is from the emitter, through the base, to the collector, a change of current of 1 mA in the emitter will cause a change of nearly 1 mA in the collector. In practice, a change of 1 mA in the emitter causes a change of about 0·98 mA in the collector; the remainder of the current flows in the base, giving a change of base current of 0·02 mA. The ratio between the collector and emitter currents is known as the current gain of the transistor, α, and equals 0·98. As the emitter is forward biased the change of current in the emitter is in a low resistance, and as the collector is reverse biased the change of current in the collector is in a high resistance. The emitter current may therefore be taken from a low-resistance source, and the collector current may flow into a high-resistance load. As the emitter and collector currents are nearly equal, we obtain a power gain from this transistor by virtue of the resistance change from emitter to collector.

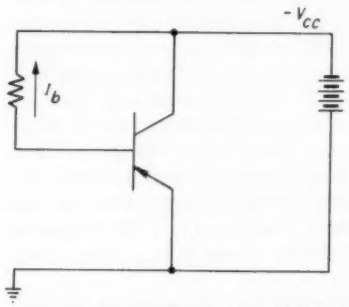


8 *Relationship between the three currents in the transistor*

The transistor is seldom used with its base common to the input and output circuits as shown in Fig. 8. It is more commonly used with its emitter common to the input and output circuits, as shown in Fig. 9. As the transistor does not know which way round it is being connected, the relationship between the three currents—the emitter, collector, and base currents—must remain the same. This means that a change of base current of 0·02 mA must cause a change of emitter current of 1 mA, and a change of collector current of 0·98 mA. The current gain therefore is 0·98/0·02, and is equal to 49; this current gain in the common-emitter configuration is known as α' or β. The resistance looking into the input is still low, as we are still looking into a forward-biased junction; the resistance looking into the output is still high, as we are looking into a reverse-biased junction. However, because of the current feedback through the internal emitter resistance, the input resistance is somewhat higher than in the common-base case, and the output resistance is somewhat lower. We can therefore obtain a gain from this configuration either by the current gain from base to collector, or by a combination of the current gain and the resistance transformation.

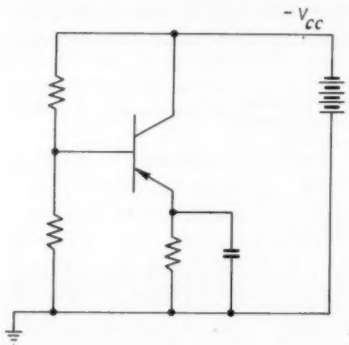


9 *Transistor arranged with emitter common to input and output*



10 (*above*) *Simple method of biasing the transistor*

11 (*below*) *Normal method of biasing*



Biasing the transistor

Having seen that we may obtain a gain from the transistor, we will now look to the d.c. biasing of the transistor in the common-emitter configuration. This could be done by applying a current bias to the base, as shown in Fig. 10. A resistor connected between the base and the supply line will supply a constant current to the base; this base current is amplified by the current gain in the transistor and gives the collector current we require. Unfortunately this simple method of biasing suffers from two practical disadvantages: first, a small thermally generated current in the collector, which we have neglected so far, flows from the collector to the base, upsets the base bias, and makes the collector

current become dependent on temperature; and secondly, there is a manufacturing spread on the value of the current gain α' which would give different values of collector current for different transistors.

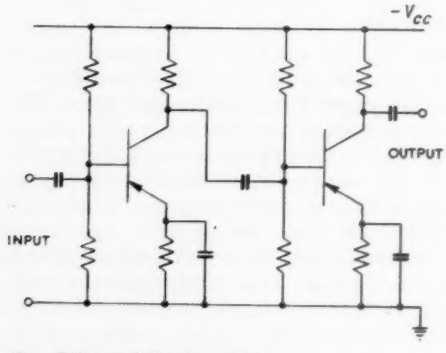
To overcome these difficulties the normal method of biasing the transistor is that shown in Fig. 11. A potentiometer from the supply line to earth is connected to the base, fixing the base potential at a certain voltage. A resistor is included in the emitter, and as there is only a very small potential difference between the base and the emitter the emitter voltage practically equals the base voltage. The resistor in the emitter then defines the emitter current, and the collector current follows from the current gain between the emitter and collector of about 0·98. As we have fixed the current in the emitter by means of the potential divider and the resistor in the emitter, the current in the transistor is virtually constant with change in temperature. The impedance of the base potentiometer is made low enough for the change of base current with temperature not to affect the potential at which the base is fixed. As this method of biasing depends on the current gain α of the transistor and not on α', it also overcomes any effect on the collector current of the spread in α' of the transistor (a large spread of α' results from only a very small spread of α, as $\alpha' = \alpha/1 - \alpha$).

The method of biasing outlined above is one which is now commonly used, and if this is borne in mind transistor circuit diagrams become more understandable. To show how transistors are used it will be necessary to divide the field of application and to give only a few examples in each division. The applications fall naturally into the following groups:

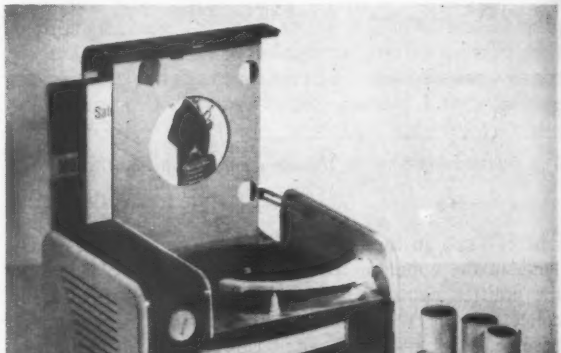
Small-signal low-frequency applications
Small-signal high-frequency applications
Small-signal switching applications
Power applications
Operation at high temperatures.

Small-signal l.f. applications

The main small-signal low-frequency application is in audio-frequency amplification. Transistors used in a.f. amplifiers are normally *RC* coupled as in valve amplifiers (Fig. 12), but although the circuits look similar it is necessary to remember that the functions of the transistor and the valve are entirely different. With the valve amplifier, voltage amplification is important; with the transistor amplifier, current amplification is the important factor. This means that to obtain maximum gain from an *RC*-coupled transistor circuit we must get as much current as we can from the preceding stage into the input of the succeeding stage. To do this the load resistance of the preceding stage is made as high as possible compared with the input resistance of the succeeding stage.



12 *RC-coupled a.f. amplifier*



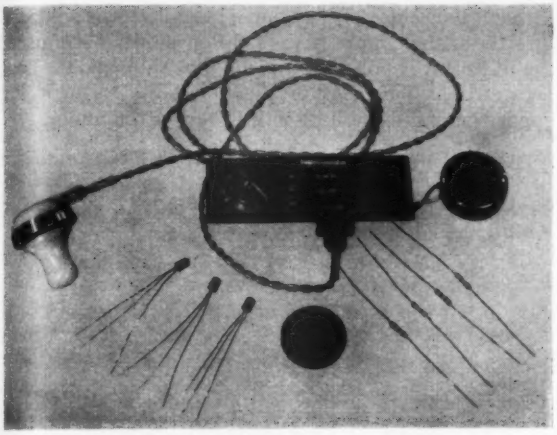
13 *A portable, battery-operated gramophone*

The best two examples of this application are the small 200 mW gramophone-amplifier and the hearing aid. The gramophone-amplifier comprises a small 45 r.p.m. turntable and a 4-transistor amplifier, having two *RC*-coupled stages and two transistors in Class B push-pull output. Class B is used because the device is battery operated and a low current consumption is essential. Such an amplifier is shown in Fig. 13. The power for both the amplifier and the turntable is derived from the four torch batteries shown.

For the hearing aid, size is all-important, and here it is necessary to produce sub-miniature transistors in order that hearing aids may be constructed self-contained with microphone, earpiece, battery and amplifier, which may be clipped directly onto the ear. Examples of these small transistors are shown in Fig. 14, where they may be compared in size with the sixpence and the hearing-aid earpiece. The hearing-aid amplifier is laid out on a panel, and the components used, although small, are being or will have to be made even smaller in the future.

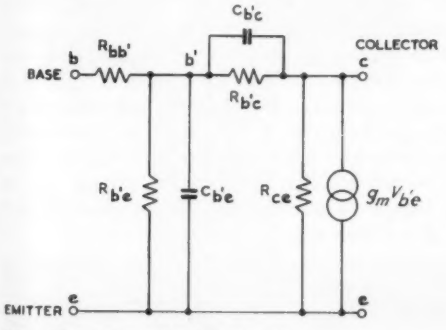
Small-signal h.f. applications

The frequency response of transistors is governed by the base width. The reason for this becomes obvious when one remembers that the holes from the emitter are diffusing through the base in a field-free region. As this process of diffusion is a random one, even if all the



14 *Transistors used in hearing aids*

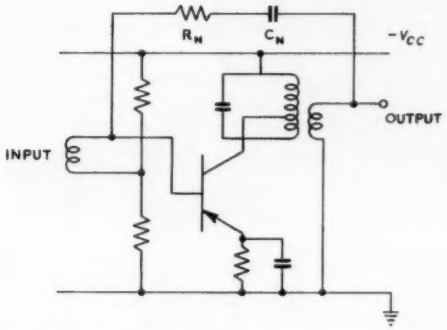
holes start from the emitter at the same time they will not reach the collector together at a defined later time. This means that the larger the base width of a transistor, the poorer its frequency response, so that transistors which are to be used in small-signal high-frequency applications have to be made with very small base widths. Even then the problem is not completely solved, as there is an internal feedback within the transistor which limits its useful gain in any h.f. circuit. This may be best illustrated by reference to an equivalent circuit representing the transistor at high frequencies, shown in Fig. 15. This is the commonly used hybrid-π common-emitter equivalent circuit; the components $C_{b'c}$ and $R_{b'c}$ provide a path for feedback from the output to the



15 *Hybrid-π equivalent circuit*

input, and in h.f. amplifiers it is necessary to neutralize this feedback to obtain a stable gain. This is done by connecting a phase-changing transformer at the output (normally tuned), and by connecting external components between the secondary and the input, thus providing an external signal to neutralize the internal feedback. An example of such a circuit is shown in Fig. 16, where R_N and C_N are the external neutralizing components. These may be fixed, as a transistor is extremely stable during life and it is unlikely that its characteristics will change sufficiently to cause instability in the circuit.

A common example of small-signal h.f. amplification is the portable battery receiver which normally uses six transistors and one diode. The first transistor is used as a self-oscillating mixer to convert the r.f. signal to the normal intermediate frequency of 465 kc/s. The second two transistors are used as i.f. amplifiers, and are followed by the diode detector, an audio amplifier, and again two transistors in Class B push-pull output to keep the battery consumption down. These transistor radios are

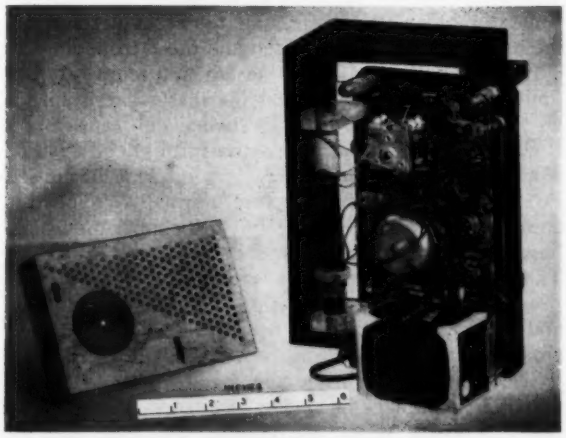


16 *I.F. amplifier*

made in sizes ranging from the normal portable to small pocket receivers. Fig. 17 shows a normal-sized 6-transistor battery portable receiver with the ferrite rod aerial on the left, the speaker in the centre with its back projecting through the chassis, the tuning capacitor at the top, and the battery at the bottom. The same receiver using a smaller aerial, speaker, tuning capacitor and battery is shown on the left.

Small-signal switching applications

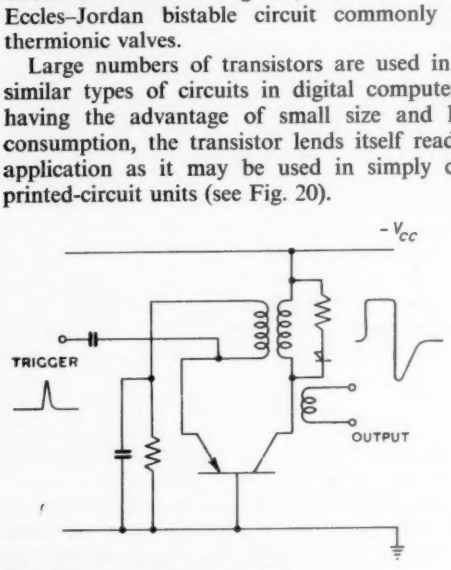
In small-signal switching applications the transistor is required to handle digital information in the form of pulses or square waves. The circuit is usually required



17 *Two battery portable receivers*

either to amplify and reshape such a pulse or to be operated by the pulse in such a way as to record the information, usually in the form of a d.c. state. An example of the first type of circuit is shown in Fig. 18. The transistor is used as a regenerative amplifier, the output from the transistor being coupled back to its input by means of a transformer. An input pulse will trigger the transistor so that it will produce an output waveform as shown. An example of the latter type of circuit is shown in Fig. 19, and is the well known Eccles–Jordan bistable circuit commonly used with thermionic valves.

Large numbers of transistors are used in these and similar types of circuits in digital computers. Besides having the advantage of small size and low power consumption, the transistor lends itself readily to this application as it may be used in simply constructed printed-circuit units (see Fig. 20).



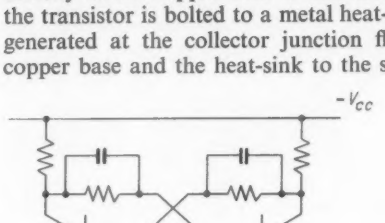
18 *Pulse-regenerative amplifier*

Power applications

The transistors considered so far are capable of handling small powers only. Two factors limit the power-handling capabilities of transistors; the first is the maximum internal junction temperature at which the transistor has a useful life, and the second is thermal resistance between this junction and the surroundings.

In germanium transistors the junction temperature is limited to about 85°C, and as the thermal resistance is comparatively high in normal small-signal transistors it is necessary to adopt an alternative form of construction if the transistor is to handle any amount of power. Power transistors are therefore normally conduction cooled by soldering the collector to a copper mounting-base, which in turn is screwed onto a metal heat-sink. This method of mounting provides a low thermal resistance between the junction and the surroundings and enables reasonable powers to be dissipated. A cross-section of such a transistor is shown in Fig. 21.

The transistor is inside the metal envelope on the right. The thin black line is the base sandwiched between the grey areas, which are indium. The base and the emitter are connected to leads which are brought out through the centre of the stud. The collector is soldered directly to the copper base of the envelope. When used, the transistor is bolted to a metal heat-sink, and the heat generated at the collector junction flows through the copper base and the heat-sink to the surroundings.

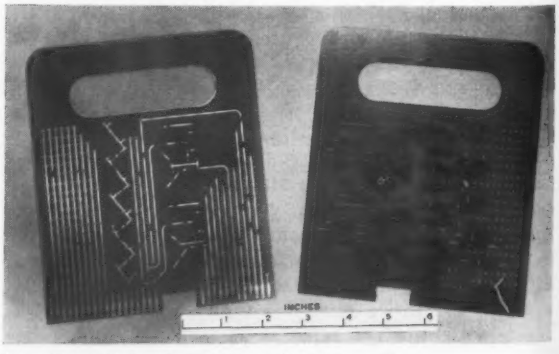


19 *Eccles–Jordan bistable circuit*

Another important factor in the design of power transistors is their current-handling capacity. As they are operated at low voltages if they are to deliver any reasonable amount of power, they must be capable of handling high currents. To do this they are generally made with junctions of fairly large area.

Car radios and computers

Low-frequency power transistors are commonly used with a.f. power amplifiers and d.c.-to-a.c. convertors. An example of the former application is the output stage of the new car radios, where thermionic valves are operated from a line voltage of 12 volts with a power transistor as an audio output stage. These car radios have the advantage that the vibrator has been eliminated and the radio will work directly off the 12-volt car battery. For battery-operated equipment where higher d.c. line voltages are required or where alternating voltages are needed to operate magnetic amplifiers and servo controls, power transistors are used in push-pull square-wave oscillators to convert the low battery voltage to an alternating voltage which may then be transformed and rectified to give a high d.c. line voltage.

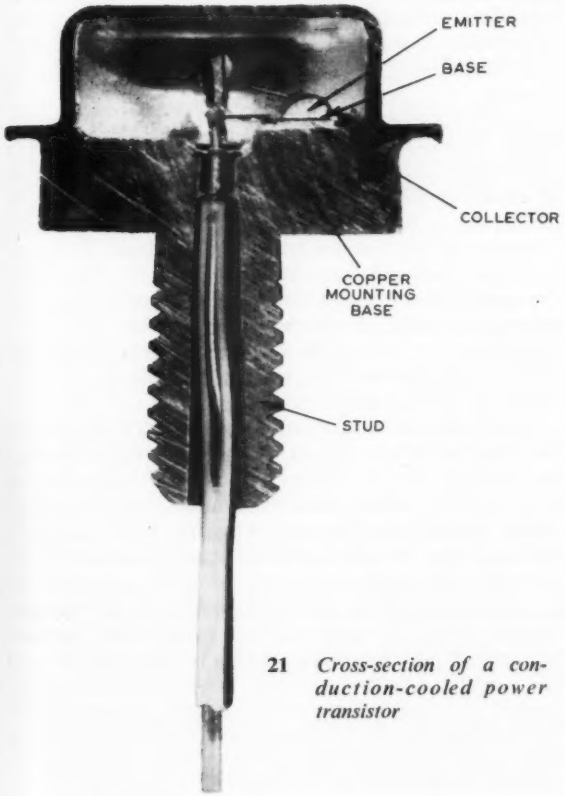


20 *Printed-circuit unit for a digital computer*

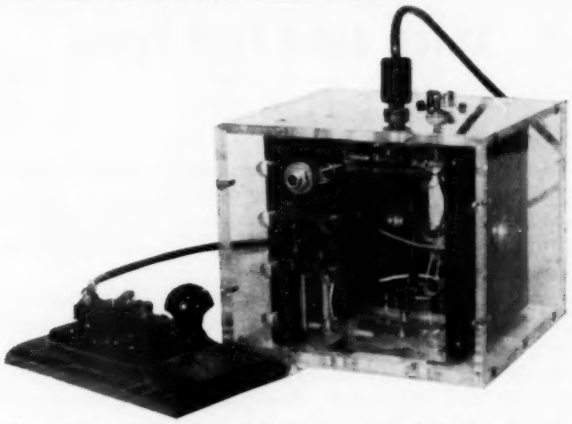
The higher-frequency power transistors find their place in digital computers to provide the high-power pulses sometimes necessary to operate storage components or a number of transistor package units, and a future use is likely in the international lifeboat distress transmitter. These transmitters are required to deliver 3 or 4 watts output at 500 kc/s. Transistors have obvious advantages of long life, reliability and small power consumption. A demonstration model for such a transmitter is shown in Fig. 22. It consists of a crystal-controlled oscillator, a buffer stage, a driver stage using an h.f. power transistor, and h.f. power transistors in Class B push-pull output. The blackened vertical plates are the heat-sinks for the power transistors, which are mounted at the centre of the plates.

Operation at high temperatures

Germanium transistors are limited to a junction temperature of about 85°C; this means that where ambient temperatures are likely to reach the region of 100°C, as in high-speed aircraft, some other material must be used. Silicon is generally used now for transistors which are required to operate at high ambient temperatures, as the maximum permitted junction temperature for silicon transistors lies between 150° and 200°C. Silicon offers the further advantage when used for power transistors that with the same thermal resistance provided by conduction cooling, the higher junction temperature permits a much higher power to be dissipated in the transistor. Apart from these differences, silicon transistors behave in a similar way to germanium ones and will be used in similar circuits.



21 *Cross-section of a conduction-cooled power transistor*



22 *Demonstration model of an international lifeboat distress transmitter*

Other uses

To conclude: it has been possible to give only a brief indication of where transistors are being used and their likely applications in the future. It has not been possible to describe their use in power-system protection, nuclear instrumentation and control, servo systems, automation, etc. Present production transistors make the use of electronics more and more attractive in more and more industries, and with the new v.h.f. transistors just around the corner and the possibility of more power at higher frequencies, there will be few fields where the transistor is not used.

Acknowledgments

The author wishes to thank the directors of the Mullard Radio Valve Co. Ltd. for permission to publish the article.

Summary

The junction transistor operates by the transport of positive or negative carriers across two junctions in a single crystal of a semiconductor material. One junction is forward biased and the other reverse biased; this means that the current flows from a low impedance into a high impedance, and so the device can amplify. In addition to this, owing to a small amount of recombination of the carriers in the base of the transistor, it is possible to obtain a current-amplification factor from the base to the collector of the transistor.

Junction transistors are now widely used in domestic, communication and control equipment. Examples of their application are the hearing aid, the battery portable receiver, the international lifeboat distress transmitter, digital computers and d.c. convertors.

ADVANCED REACTORS 539.17

2. Later Solid-Fuel Types

In the first part of his article, published in the October Journal, Dr. Dunworth discussed those reactors in stage 1 and stage 2 of the United Kingdom Atomic Energy Authority's programme which the Authority had considered or were still considering.

Other reactors were classed as stage 3 in the Government White Paper of 1955, and they are unlikely to come into commercial operation until after 1970. The majority do not have complete mechanical separation of fuel, coolant and moderator; they possess a highly active circuit, with the fuel in suspension or solution.

There are, however, two important reactors in this class which have a solid fuel—the fast reactor and a high-temperaure gas-cooled thermal reactor—to which this second part of the article is devoted.

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ASSOCIATE MEMBER

IN this country, until recently, a major attraction of the fast reactor was that the system can breed its own fuel supply of plutonium. After the initial charge of natural-uranium fuel has been provided for the blanket, fast reactors can, in theory, furnish all the electricity in this country for a total feed of only 15 tons of natural uranium per year.

However, in the last few years this situation has changed, since large amounts of natural uranium have been discovered. Consequently, there seems to be no immediate danger of scarcity. As a result, the fast reactor will have to compete for at least 40 years with stage 1 and 2 systems which use natural, or slightly enriched, uranium and consume only about 1% of the usable energy. After this very low usage in a stage 1 or 2 reactor, the spent fuel can be discarded on economic grounds and placed in store against the day when it may be economical to recover it for a fast-reactor blanket.

Dounreay fast reactor

The fast-reactor development in this country has involved a programme of research, the building of two zero-energy reactors at Harwell, known as Zephyr and Zeus, and the construction of a reactor experiment at Dounreay. The first of the zero-energy reactors—Zephyr—had a fuel charge of plutonium and was used for preliminary exploration of the fast-reactor concept.

1 *General view of Dido high-flux research reactor*
It is used primarily for neutron irradiation of solids, liquids and reactor components likely to be of interest in reactor technology

Zeus was used to investigate detailed points in the design of Dounreay, which will have a heat output of 60 MW and an electrical output of about 15 MW. The capital cost of this project will be of the order of hundreds of pounds per installed electrical kilowatt. A prototype will be different in detailed design and possibly in concept.

One of the most crucial design problems is that a fast reactor requires a very high density of fissile material in the core, as fast fission cross-sections are less than $\frac{1}{100}$th of those for thermal neutrons. (The neutron spectrum has a peak at an energy of about 0·2 MeV.) As a result, very high power densities are required in the core, or fuel-inventory charges become prohibitive. Table 1 illustrates this point. Dounreay has a core of highly enriched fuel containing roughly equal amounts of U235 and U238. The rods are canned in niobium, produced by the U.K.A.E.A. Industrial Group in collaboration with industry (see Fig. 5).

After operational experience has been gained, some of the core fuel will be changed to plutonium, the eventual basis of fast-reactor development. The blanket fuel in Dounreay is natural uranium canned in stainless steel. Later, thorium may be substituted for natural uranium to determine the characteristics of the thorium–U233 cycle in a fast reactor.

Sodium–potassium alloy will initially be the primary coolant, since it is liquid at room temperature, and will be replaced later by sodium, which is much cheaper and has a melting point just below 100°C. Control of the reactor is by means of groups of core elements which can be raised and lowered vertically. In addition, there are safety rods containing boron10. Inlet and outlet temperatures of the coolant are 200° and 350°C respectively.

Table 1. Reactor power densities

Reactor	Completion date	Core size, ft unless stated	Vol., kilolitres	Over-all size, ft unless stated. Either core and reflector or core and blanket	Vol., kilolitres	Max. thermal power, MW	Power density, kW/l	
							Core	Over-all
Gas-cooled systems								
Bepo ..	1948	20 dia. × 20	178	26 dia. × 26	390	6	0·03	0·015
Calder ..	1957	31 dia. × 21	450	36 dia. × 27	780	180	0·4	0·23
Hinkley ..	1961	49 dia. × 25	1340	50 dia. × 30	1650	980	0·73	0·59
H.T.G.C. ..	proposal only	124 cm dia. × 124 cm	1·5	10½ dia. × 8	19·5	20	13·0	1·0
Water-cooled systems								
NRX ..	1947	8¾ dia. × 10½	18·6	14½ × 16	72·5	40	2·2	0·55
MTR ..	1952	4½ × 3	1·36	9·3 × 12 × 14	44	30	22·0	0·68
Dido ..	1956	34″ × 28″ × 24″	0·375	6½ × 8 (excl. reflector)	7·5	10	27·0	1·3
				10½ × 13 (incl. reflector)	31·7			0·32
PWR ..	1957	6·8 dia. × 5·9	6·05	9 dia. × 10	17·9	231	38·0	13·0
Boiling-water systems								
EBWR 2 ..	1957	4 dia. × 4½	1·6	7 dia. × 7½*	8·2	20	13·0	2·5
VBWR ..	1957	3 dia. × 3	0·6	7½ dia. × 7*	7·6	30	50·0	4·0
Aqueous homogeneous systems								
PAR ..	proposal only	14 dia. (sphere)	40·6	14 dia. (sphere)	40·6	550	1 zone	14·0
HRT ..	1957	32″ dia. (sphere)	0·27	5 dia. (sphere)	1·84	10	37·0	5·5
Organic liquid-cooled systems								
OMRE ..	1957	22¼″ dia. × 36″	0·234	4½ dia. × 5*	2·25	16	68·0	7·1
Liquid-metal-cooled systems (thermal)								
SGR ..	1958	13·3 dia. × 10	392	17·3 dia. × 14	93	250	6·4	2·7
LMFR ..	proposal only	5 dia. × 5	2·78	12 dia. × 15	48	550	200	11·0
Liquid-metal-cooled systems (fast)								
EBR 1 ..	1950	7½″ hex. × 8½″	0·0068	31″ dia. × 35″	0·433	1·4	148	3·2
Dounreay ..	1959	21″ hex. × 21″	0·131	6 dia. × 8	6·4	60	460	9·4
Enrico Fermi	1960	30½″ dia. × 31·2″	0·370	78·2″ dia. × 67″	5·3	300	720	57

* In liquid-cooled and -moderated systems, exact reflector height is difficult to ascertain. The figures quoted are reasonable assumptions

A secondary liquid-metal coolant circuit is employed to act as an isolating barrier against danger which might result from water entering the primary-coolant circuit or coming into contact with the highly radioactive primary coolant.

EBR 1

A small fast reactor EBR 1 was built in Idaho some years ago. After several years' operation an accident occurred, resulting in the melting of some of the fuel elements in the core. The accident happened during experiments to determine the transient response of the reactor, not during normal operation, and did not have serious consequences. The reactor core has now been rebuilt.

Some characteristics of this reactor are given in Table 2. The core-fuel rods are about 0·3 in. in diameter and are nearly pure U235 jacketed in stainless steel. Surrounding the core is a blanket consisting of 1 in.-diameter natural-uranium rods clad in stainless steel 0·020 in. thick.

EBR 2

An experimental reactor EBR 2 is being built at the Idaho reactor-testing station by the U.S. Atomic Energy Commission to designs prepared at the Argonne National Laboratory. It will have a heat output almost identical with that of Dounreay. The fuel in its core will be thin plutonium rods clad in stainless steel.

Steam will be obtained at about 450°C and 1250 lb/in.², and a conventional 20 MW generator will be fitted. The primary-coolant flow rate will be about 2000 tons/h of sodium, entering the reactor at about 400° and leaving at around 475°C. The secondary-coolant flow rate in the intermediate heat-exchanger circuit will be about 1000 tons/h and the temperatures at inlet and outlet 300° and 450°C, respectively.

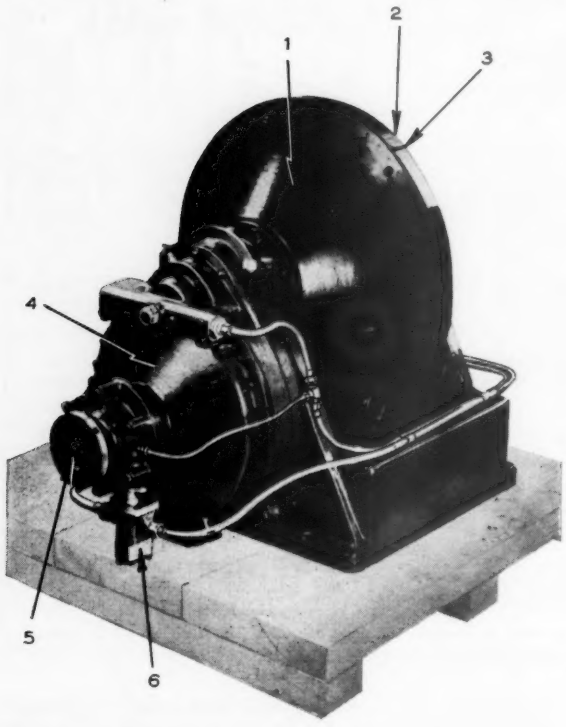
Table 2. Engineering data for EBR 1 fast reactor

Reactor core and internal blanket	
Temperature sodium in	228°C
Temperature sodium out	316°C
Flow rate	292 g.p.m.
Total heat produced	1400 kW
Heat produced in core	1008 kW
Heat produced in internal blanket	196 kW
Core	
Total fuel-rod surface area	15·68 ft²
Average thermal flux	209000 B.Th.U./h/ft² (15·7 cal/s/cm²)
Temperature at centre of fuel rod adjacent to centre rod	357°C
Temperature difference between rod centre and surrounding sodium	770°C
Average specific power	18·1 kW/kg fuel
Cross-sectional area for coolant flow	0·1008 ft²
Coolant velocity	6·5 ft/s

Cost of processing

In a thermal fission reactor, it is possible to obtain a relatively high burn-up of fissile material in a fuel element by diluting the fuel with inert material. In this way, radiation damage to the fuel element can be greatly reduced for a given fractional burn-up of the fissile material. In the case of a fast reactor, and especially in the core, it is not possible to dilute the fissile material to any great extent.

As a result, it may be possible to consume only a few per cent. or even less of the fissile atoms in a fuel element before processing becomes necessary because of metallurgical deterioration of the element. The cost of processing must be small compared with the value of the material being processed, or fuel costs in an operating power reactor will be prohibitive. Also, fissile material in the processing plant is a stock associated with the reactor system and must be kept to a minimum. The normal cooling time of several months between removing the fuel element from a reactor and chemical processing must be avoided if possible.



2 *A neutron chopper*

It creates pulses of neutrons by means of a rotor containing slots of neutron-absorbing matter. Time-of-flight techniques can be used to identify and apply neutrons of a given energy

1 Chopper 2 Narrow end of a slit 3 Wide end of a slit
4 Housing for 7:5:1 gear 5 Flange connection for driving shaft
6 Oil pump

Further, the fuel element will contain plutonium and could not be directly handled during refabrication. Remote handling will make unnecessary the complete removal of fission products before refabrication, since the operator can work from behind a shield. In addition, fission products are not a significant poison in a fast reactor, which favours a simple and incomplete decontamination.

New processing schemes

Therefore, consideration has been given to the design of a fuel and processing plant directly associated with the EBR 2 reactor system. In particular, Argonne staff are working on high-temperature methods of processing fuel which would leave it in a metallic state throughout. In the preferred scheme, core-fuel elements will be held in a molten state in an oxide crucible. Volatile and gaseous fission products will be evolved, while other highly reactive products will be removed by reaction with the crucible. The remaining fission products (niobium, molybdenum, technetium, ruthenium, rhodium and palladium) will not be removed, as they are believed to improve the radiation stability of the fuel.

Oxidation reactions such as the formation of halides and carbides have also been investigated for the selective removal of fission products. Another idea is to dissolve the molten fuel in zinc or mercury. Fractional crystallization of an intermetallic compound would remove the fuel from the bulk of the fission products. The fuel would be recovered from the intermetallic compound by vaporization of the other metallic constituent.

Processing schemes such as these are in preliminary development, since they much depend on the nature and

Table 3. Enrico Fermi fast reactor

Reactor and plant		
Gross electric capacity		100 MW
Net electric capacity		90 MW
Power (heat)		300 MW
Core diameter		≃ 3 ft
Core length		≃ 3 ft
Over-all height of reactor vessel		35 ft
Outside diameter of reactor vessel		14·5 ft
Max. thickness of reactor vessel		2 in.
Core-sodium flow rate		11·88 × 10^6 lb/h
Core-sodium velocity		32·5 ft/s
Over-all height of containment vessel		120 ft
Inside diameter of containment vessel		72 ft
Thickness of containment vessel		1 in.
Liquid metals and steam systems		
	Net thermal efficiency	30·0%
Primary circuit	Sodium temperature: entering reactor	288°C
	Sodium temperature: leaving reactor	316°C
	Sodium flow	13·2 × 10^6 lb/h
Intermediate circuit	Sodium temperature: entering boiler	407°C
	Sodium temperature: leaving boiler	268°C
	Sodium flow	13·2 × 10^6 lb/h
	Steam pressure	600 lb/in.^{2}
	Steam temperature	402°C
	Feed-water temperature	204°C
	Steam flow	1 × 10^6 lb/h

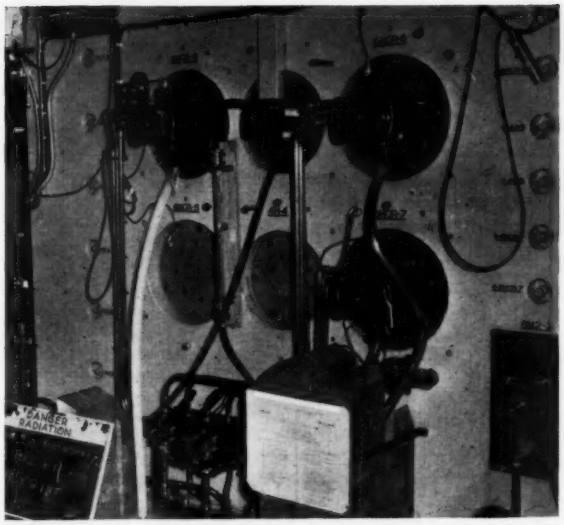
design of the fuel and its canning. It is clear, however, that the fuel element in a fast reactor must be simple, so that it can be made cheaply by remote means. The processing situation will change radically if a ceramic or cermet fuel is developed.

Enrico Fermi fast reactor

A group of companies in the United States are developing near Detroit the Enrico Fermi fast reactor. Ground was broken in 1956, and it is hoped to be in operation about the end of 1960 (see Fig. 6).

Some of the parameters of this reactor are given in Table 3. The core of the reactor lies between 18in.-long blankets and consists of sections made up of 144 zirconium-clad fuel pins bonded together on a square pitch of 0·184in. The pins have an outside diameter of 0·158in., and the zirconium cladding is 0·004in. thick. The fuel is three atoms of U238 to one of U235 and contains 10wt.-% of molybdenum for improved radiation stability. Even so, it is expected that only 10% of the U235 will be fissioned before processing. The reactor blankets contain 0·5in.-diameter rods of natural or depleted uranium canned in 0·10in.-thick stainless steel. The coolant will be liquid sodium in primary (stainless steel) and secondary (low-alloy carbon steel) circuits.

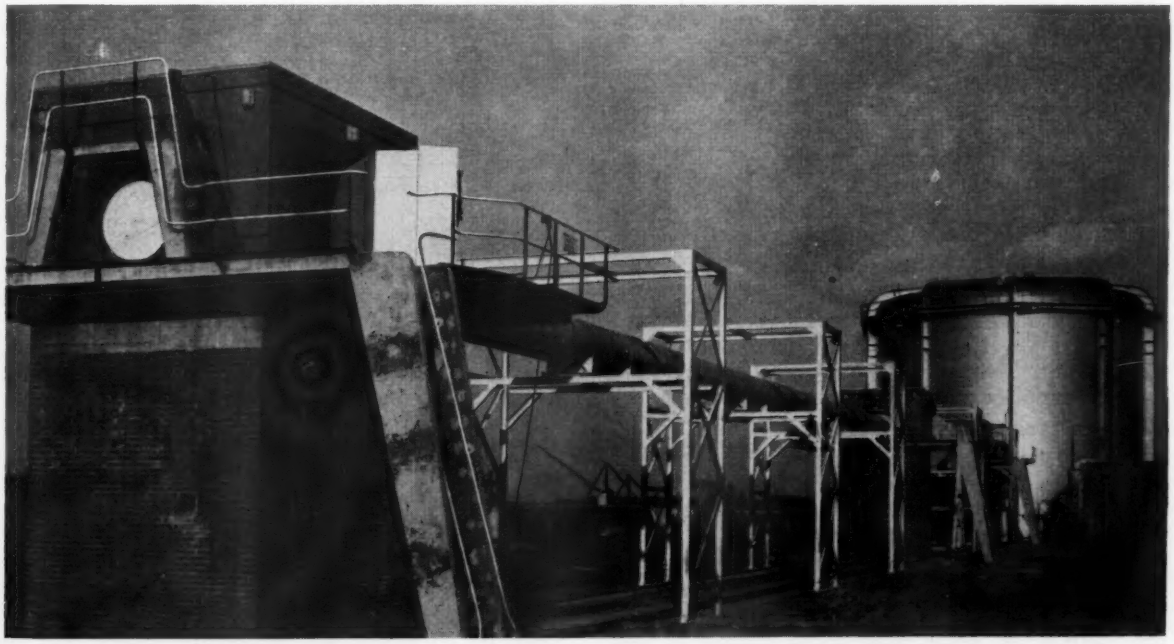
This is a rather larger reactor experiment than is being attempted either in this country or by the Argonne National Laboratory and should facilitate the construction of a full-scale plutonium breeder reactor.



4 *View of one face of Dido, showing the gear for inserting a sample and withdrawing it after a short time without closing down the reactor*

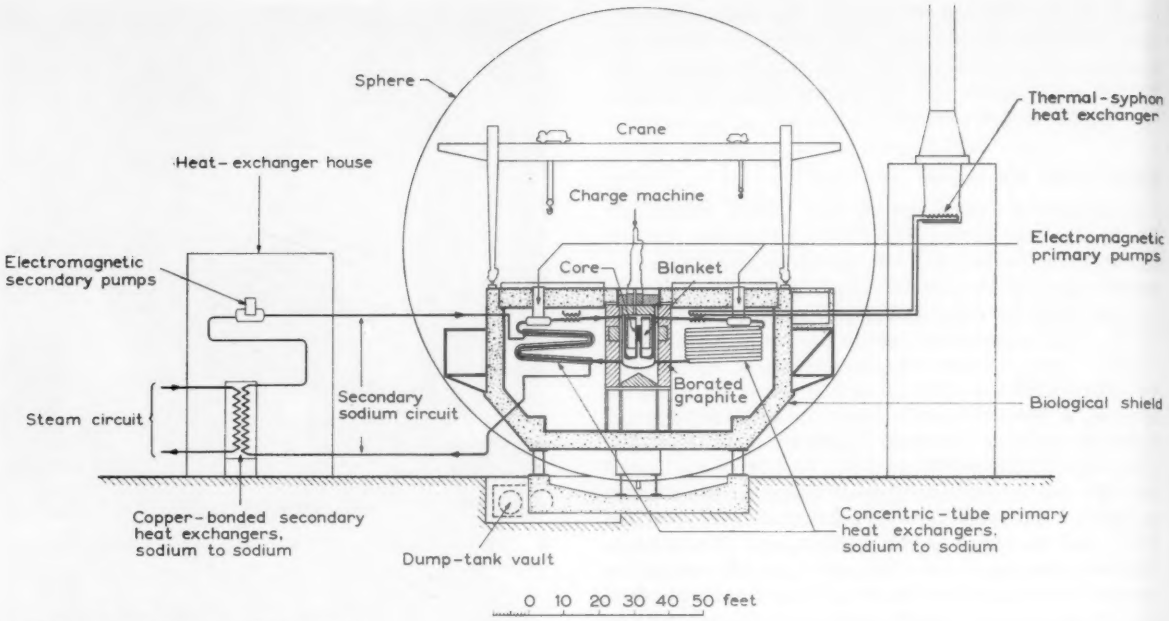
Fast thermal reactor

The core of a fast reactor is 50–80% fuel element and structural materials and the rest coolant. On loss of coolant, either directly or because of a nuclear runaway,



3 *Dido-reactor flight path for neutrons*

The velocity of neutrons selected is given by the flight-path length divided by the period from when the chopper pulse occurs (see Fig. 2) to the time when the detector is momentarily sensitized



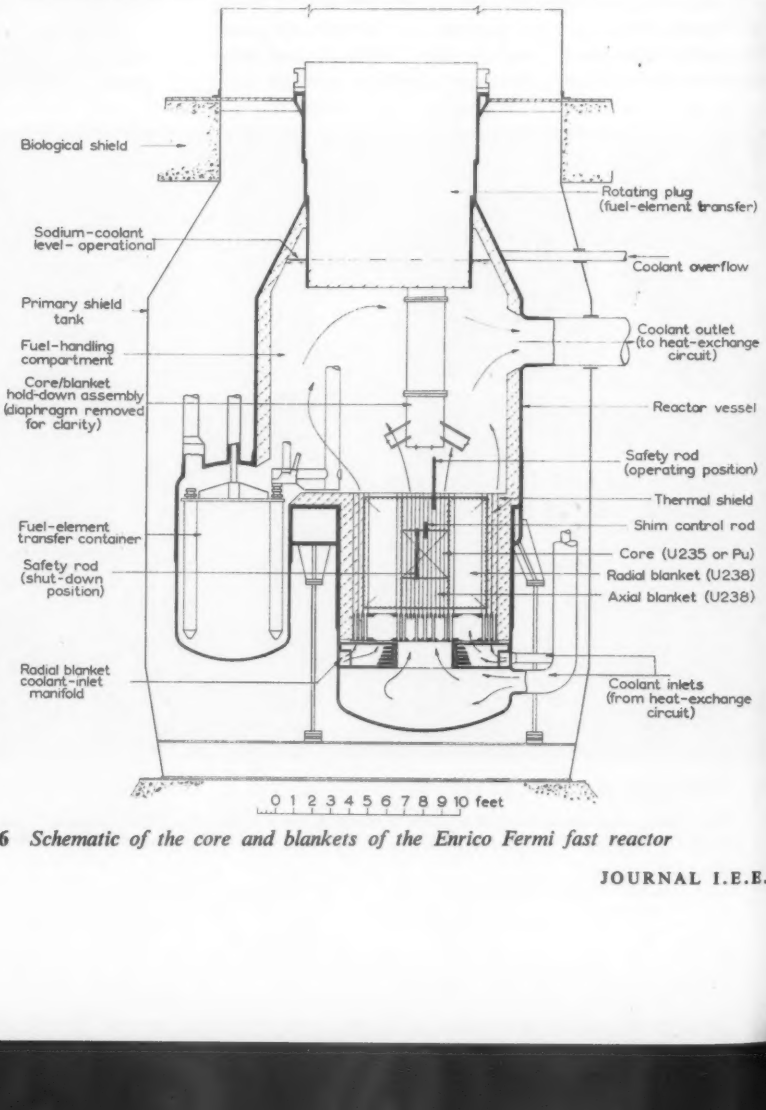
5 *Schematic of Dounreay fast reactor*

the fuel which melts first may occupy the coolant space in another part of the core. This leads to complex control and design problems.

For this reason and to ease control generally, the experiment has been tried of introducing moderating material between an inner and outer blanket of a fast-reactor system. By making the reactor about 5% subcritical on a fast-neutron chain reaction, neutron lifetimes of the order of 10^{-5} sec are achieved, as compared with about 10^{-7} sec for a 'non-thermalized' reactor. British experiments have been made on the Zephyr reactor at Harwell. In the United States, beryllium has been used as the moderator.

Ceramic and cermet fuels

One problem of a fast reactor is that present types of fuel will have to be processed many times before all their fissile atoms are consumed. An alternative is to use ceramic or cermet fuels, which have greater resistance to irradiation. Unfortunately, the oxygen, carbon or other light atom associated with the ceramic fuel and the diluent in a cermet reduce neutron economy.

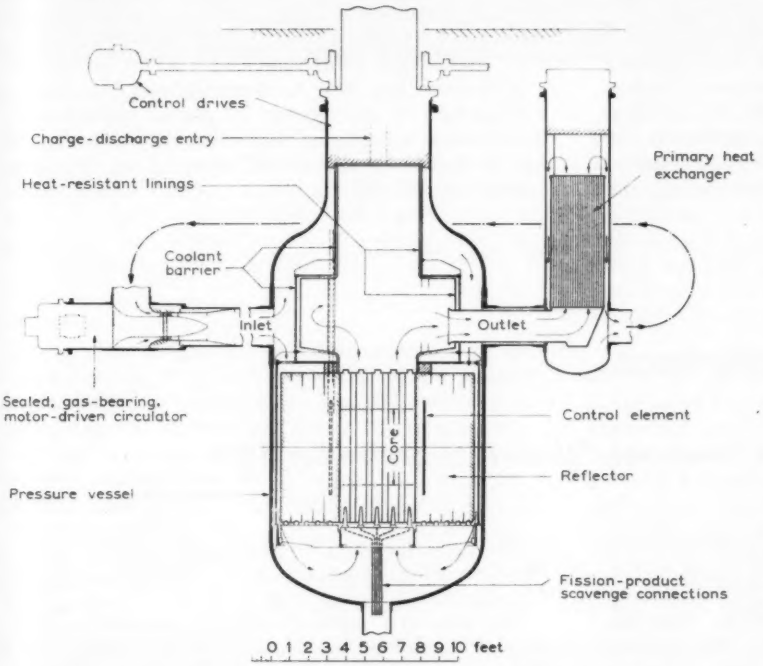


6 *Schematic of the core and blankets of the Enrico Fermi fast reactor*

However, these ceramic and cermet fuels represent a real and definite possibility of making fast reactors more attractive economically, by reducing the scale of the processing problem.

Molten fuels

Another fast-reactor scheme recently considered uses plutonium either in metallic solution or in some form of slurry. Fuel would not circulate through the core and through a heat exchanger, since, at the present time, fuel hold-up would be unacceptable and the nuclear instabilities which could result look decidedly dangerous.



7 *Schematic of a high-temperature gas-cooled reactor (10 MW experiment)*

To explore this concept, a 1 MW sodium-cooled reactor LAMPRE 1 has been designed in the United States. A liquid 90%-plutonium–iron alloy which melts at about 400°C will be contained in a tantalum vessel through which the coolant tubes pass. The whole reactor, including core and reflector, will be assembled in a stainless-steel vessel about 1 ft in diameter and 7 ft long.

General observations on fast reactors

There seems no immediate likelihood of fast reactors entering service in commercial generating stations. Much development is needed of a core design with rating adequate to ensure operational economy, as well as of a cheap but safe heat exchanger. Work on fuel elements is necessary, and on fuel processing, so that total fuel costs can be reduced.

We must not regard the fast reactor as a means of rapidly increasing our stocks of fissile material, but as a device whereby we can maintain our stocks and in which we can consume U238. Only in the fast reactor can we consume this fertile material.

Since the fast reactor has no moderator and is compact, it should be possible to design for fairly low capital costs, though fuel-inventory charges may be troublesome. We are freer as regards neutron absorption in our choice of materials than with a thermal reactor. In particular, we can use steel without undue restriction. The fast reactor is reasonably free from problems such as that of xenon poisoning. Sodium seems the correct coolant, but it is not the only one which can be used.

The high-temperature gas-cooled reactor

Serious consideration is being given in the United Kingdom to the high-temperature gas-cooled reactor. It is not a single concept but a family of concepts, and the ultimate best design is still far from clear. The choice of technology may be different for various applications (see Fig. 7).

The fuel, instead of being separate, is associated directly with, and may be regarded as being diluted by, the moderating material. There may be additional moderating material, between individual fuel elements. Temperatures as high as 1000°C for the surface fuel and 1500°C for the centre are proposed. Graphite moderator may be used initially, because it is immediately available.

Plans exist for building a small reactor experiment in the United Kingdom. To minimize the chemical problems, it is intended to use helium coolant at about 10 atm in this first experiment. Even so, fairly high-purity helium will be needed to prevent chemical action and mass-transfer effects with the moderating material.

Alternative concepts

If we use graphite to contain the fuel, we must reduce to a minimum the escape of fission products into the coolant gas. We can do this, on the one hand, by developing a relatively impermeable graphite and, on the other, by so designing the fuel that a bleed can be taken to a fission-product trapping system from inside what may be regarded as a graphite can.

This idea is elaborate, and inevitably thoughts are directed towards alternative concepts of the high-temperature gas-cooled system. The really crucial

question is whether some form of canning material can be devised for the composite fuel element which will withstand high temperatures and, at the same time, be very highly impermeable. It is probable that steel canning can be used up to 750°C, though the nuclear economy would be seriously affected. The alternative, a completely impermeable ceramic can, is most attractive. Successful development of such a ceramic can would make a great difference to the scale of utilization of this reactor system.

The choice of gas coolant is restricted: with a graphite system, nitrogen is probably the only gas, other than helium, which can be seriously considered. We may, however, be able to employ carbides or the beryllium atom as moderating material. With beryllium, we may contemplate using carbon-dioxide coolant. The carbon-dioxide-cooled system, in which fission materials are retained inside a fuel element, could, indeed, be regarded as the ultimate development of the Calder Hall system.

General observations on H.T.G.C. reactors

For large nuclear-power stations, it is quite possible that the high-temperature gas-cooled reactor would use some form of gas-turbine circulator within the circuit itself for providing coolant flow, but that electricity would be generated by advanced steam-turbine equipment. Gas temperatures under consideration are 750°C at reactor outlet, 600°C at circulator outlet, and 350°C at reactor inlet, giving an over-all efficiency of about 40%.

For alternative applications, and especially where modest outputs are required, the reactor has an obvious association with gas-turbine generating equipment, and such systems offer promise of a high power/weight ratio.

It is much too early to determine the time scale of development of this reactor, its precise application, or the forms it will assume. The most important requisite for its success is the development of an impervious ceramic can for the fuel.

The World Power Conference

Twelfth Sectional Meeting in Montreal, 7th to 11th September 1958

THE Canadian Sectional Meeting of the World Power Conference was held in Montreal from the 7th to 11th September 1958. Montreal proved a perfect place for the meeting, which dealt largely with energy—resources, production, transportation and utilization. One complete floor of a new hotel, the Queen Elizabeth, claimed to be the largest in the British Commonwealth, was devoted to the needs of the Conference.

The hotel has a large *salon* in which lectures and other functions took place and where on occasion wonderful meals were served. This room easily holds 1500 people. The floor has a large number of other rooms of different sizes suitable for small lectures or meetings. The whole arrangement was ideal and gave considerable satisfaction to the 1000 delegates from 52 member nations who attended.

Official Opening

The Canadian National Committee had prepared an extensive programme of events for the interest and entertainment of delegates. The programme was begun at 3 p.m. on Sunday, 7th September, with the official opening under the Presidency of Gen. Dir. Franz Holzinger. The Conference was welcomed to Canada by the Hon. Alvin Hamilton, Minister of Northern Affairs and National Resources, representing the Prime Minister, Mr. John Diefenbaker. His welcome was supported by the Hon. Paul Beaulieu, Quebec Minister of Trade and Commerce, on behalf of the Provost; by His Worship Mayor Sarto Fournier of Montreal; and by Maj.-Gen. H. A. Young, C.B., C.B.E., D.S.O., on behalf of the Canadian National Committee.

Responses were made by delegates representing various National Committees, including Mr. W. H. Connolly, Chairman of the Australian National Committee; Sir Harold Hartley, G.C.V.O., C.B.E., F.R.S., Past-President of the Conference and Hon. Chairman of the International Executive Council; Minister A. S. Pavlenko, Chairman of the National Committee for the U.S.S.R.; and Mr. J. S. Duncan, C.M.G., representative of the International Chambers of Commerce.

In the evening a reception and buffet for all delegates and their wives took place in the *salon*. This was a happy and pleasant occasion, when many friends had the opportunity of informal discussion and renewed acquaintanceship.

Technical Programme

A large number of papers had been submitted for the technical programme, which was divided into these sections:

Production—covering hydraulic energy, electrical energy generated from conventional fuels, and electrical energy derived from nuclear fuels

Transportation—comprising electrical transmission and the carrying of fuel by rail, water and pipeline

Utilization—including the employment of energy in industry and commerce; utility financing and tariffs; and usage in farms, residential areas, and transportation.

The opening session of the Meeting

The technical sessions, which were held morning and afternoon on Monday, Tuesday, Wednesday and Thursday, 8th to 11th September, were very well attended, and the discussions were most useful. For delegates not involved in the technical sessions, visits were arranged to view interesting parts of the St. Lawrence Seaway Project in the vicinity.

Social Events

A large social programme had been arranged for the delegates and their wives, including a reception on Monday evening given by the Quebec Hydro-Electric Commission in the *salon*. This was followed by a dinner, by courtesy of the Commission, at which the whole Conference was entertained with great Canadian hospitality.

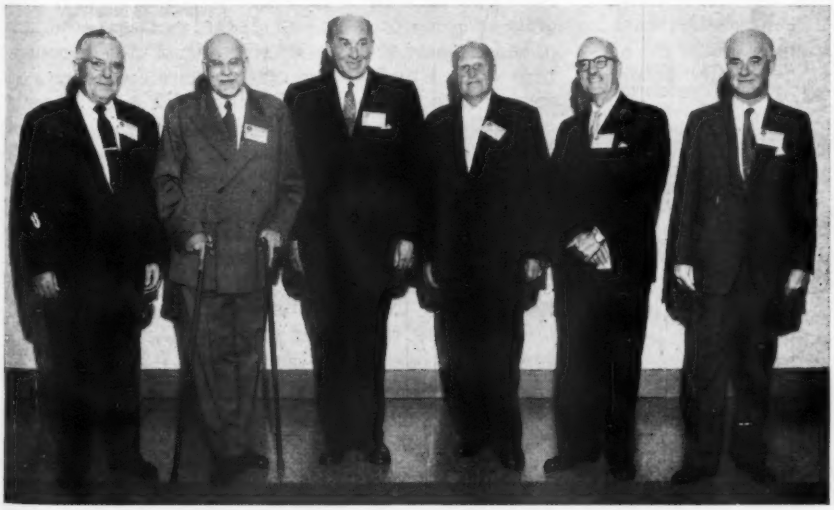
On Tuesday an informal dinner, and a pantomime presented by an amateur company, were much enjoyed by all members, but particularly by those who understood French. On Wednesday evening the Conference delegates were the guests of the City of Montreal at the Chalet on Mount Royal. The views from the eminence of the city, including the harbour and the St. Lawrence River, will long be remembered.

On Thursday, 11th September, the closing ceremonies of the Canadian Sectional Meeting took place; and a series of resolutions of thanks were passed by the Conference Committee, under the chairmanship of Sir Vincent Z. de Ferranti, M.C., Chairman of the International Executive Council and a Past-President of The Institution.

Sightseeing

The ladies were well looked after by the Canadian Ladies Committee, under the able chairmanship of Mme. C. Taschereau and Mrs. Grange Kingsmill. The committee provided a programme of most interesting events, such as sightseeing in Montreal; a fur fashion show (well attended, but no free samples!); and a series of coffee mornings at which the ladies were able to gather and exchange reminiscences.

Altogether, this Canadian Sectional Meeting will be remembered by all delegates for a great and friendly Canadian welcome and for the wonderful facilities offered by Montreal for such a Conference. Most delegates left at the end of the Meeting to continue their studies in a series of post-Conference tours of large hydro-electric generating stations in northern Canada, and also to see something of the nuclear reactor at Shippingport and other places of interest in North America.



Conference officers at a reception

From left to right are G. A. Hathaway, Vice-Chairman of the Council; Sir Harold Hartley, Honorary Chairman of the Council; Maj.-Gen. H. A. Young, Vice-Chairman of the Council; Franz Holzinger, President of the Conference; Sir Vincent Z. de Ferranti, Chairman of the Council; and C. H. Gray, Secretary

It was announced on the 6th September that the 1962 plenary meeting of the World Power Conference would be held in October that year, at the University of Melbourne, Australia. The theme of the meeting will be 'the changing pattern of power'. The sectional meeting in 1960 will take place in Madrid.

Three more nations: Peru, the Federation of Rhodesia and Nyasaland, and Uganda, were admitted to membership. H. W.

The Four Pillars of The Institution

2 THE SUPPLY SECTION

HOMO SAPIENS could be described as having four principal characteristics: the ability to communicate with his fellows; the power of adaptation and the use of tools; the capacity to develop judgment and control; and physical energy. It is the last that makes the others possible, for a man without physical energy is already dead. Fancifully, perhaps, these four characteristics may be likened to those of engineers in the electrical industry, and used to describe the functions of the professional members of The Institution's four Sections. Engineers of the Supply Section, by and large, produce the energy which makes the others 'tick'.

No one Section *is* The Institution. All are essential to it and to each other, inseparable as Siamese quads or the four corners of a square. Modern supply could not be carried on without the arts of communication, control and metering, from system communication and load flow down to the humble telephone and humdrum house meter. Nor would the production of energy be of any use without the multifarious means of applying and utilizing it.

The Supply Section's interests embrace the whole of the energy-producing branch of electrical engineering, from the generating station through the transmission and distribution network to the substation. Its 'aspects' cover the study, design, manufacture, control, installation, operation, application, employment, maintenance and protection of this plant. The numerical strength of the Section is well over 5000: its leitmotiv is the megawatt-hour.

Electrical energy is a necessity of modern civilized life. The improvement in the efficiency and effectiveness of energy production is, in no small measure, due to the work of the Section. Let us be accurate: it is due rather to the research, foresight, understanding, inspiration and sheer hard work of those engineers who recognize the Section as their forum and whose interest and support have given it such vitality.

Essence of Parliament

The Overhead Lines Association was born in 1927, when high-voltage transmission in Britain was gathering momentum. This healthy infant was adopted by the Council of The Institution in 1933, renamed the 'Transmission Section', and received into its future home in the following year. The first Chairman was R. Borlase Matthews, a pioneer in agricultural electrification. He was introduced at the opening meeting on the 21st November 1934 by the reigning President, Prof. W. M. Thornton. The important change of scope, and the alteration in name to its present form, were made in 1948. Thus the Supply (*née* Transmission) Section has had a quarter-century of active corporate life.

But the art, or craft, or science (or what you will) of electricity supply is very much older. It may even be centenarian, depending on the way one defines 'supply'. In the century the pattern of supply has not only grown immensely, it has changed out of recognition.

The pioneers of the early days were untrammelled by standardization. Any voltage, any frequency, could be found in Britain at the turn of the century. Contiguous areas, each with its pocket-sized power station in a back street, existed side by side with the most irreconcilable types of supply imaginable. Interconnection was forbidden by Parliament in its wisdom—although how such interconnection could have been brought about in the circumstances is rather difficult to see.

The systems had their protagonists. Lord Kelvin, in well turned and cogent phrases, pressed the claims of direct current as the only rational form of supply and prophesied the demise, sooner or later, of distribution by alternating current. At our own point in time we see that he was wrong. It is, however, salutary to remember that one day engineers may quite well say the same about us, for reasons that we do not yet realize but which will seem good to them. The inevitability of change is progress, and progress is a building of the present on the past.

The progress of supply has, at any rate in this country, been dogged by legislation, not always enlightened (in spite of such titles as 'The Electric Light Act'). The Act of 1882 brought local authorities into the ranks of approved suppliers—and the nationalizing Act of 1947 pushed them out again. The Electricity Supply Act of 1919 fathered the Electricity Commissioners; and seven years later came a really epoch-making advance, establishing the Central Electricity Board, with powers to concentrate public supply into 'selected stations' and standardizing the alternating-current system at 50c/s.

Since then, the jigsaw of Areas and the slightly bewildering title-shuffling are facts of recent history. So also are the sad days of 1947, with fuel crises, load shedding, rationing, and overcoats-in-the-office: a taste (and not a pleasant one) of life without a reliable electricity supply.

Floreat Copia

Supply is today a flourishing industry. During the last 30 years the amount of coal directly burnt 'raw' has declined, the amount used as gas or coke has increased by

half, and that supplied as electrical energy has increased eight times. From a fabulous cost per unit in the early days we have come to a cheapness such that a labourer can earn the price of a unit (but no longer the price of a pint) by a mere two minutes' work. Electricity powers factories, controls trains, provides a new high level of home comfort.

There is a glamour and attractiveness about the achievements of energy supply of which young engineers, blinded by 'electronics', are too often unaware. Even the advent of nuclear energy has done little in redress. Yet the achievements are massive. The mighty hydro-electric stations on the Volga and Columbia Rivers are matched by the hydro developments of Scotland, made in face of a scattered smallness. The 400 kV Kuibichev transmission line has a British counterpart in Rhodesia, not to mention the Supergrid at home. Submarine power cabling and nuclear-energy stations have been pioneered in our time. Pumped storage provides for the alternating-current network what the battery substation (which so attracted Kelvin) did for the direct-current system. Generators and transformers have reached the giant class. Engineering problems of great complexity and absorbing interest are being solved, and intensive research is being carried on.

All this surely holds inspiration for the best of the up-and-coming young engineers? Achievements as yet only dreams (the fuel cell? nuclear fusion?) gestate in the womb of the future. Fifty years hence we may see world-owned solar-energy plant in the Sahara. What has been done so far is still only a beginning.

Facts and Figures

It is in this climate that the Supply Section works. It is the second largest of the four. At the beginning, in 1934, there were fewer than 1300 members: now the number approaches 5300. Its members derive inspiration and corporate feeling from its meetings, not only in London but in Birmingham, Bristol, Cardiff and Manchester as well.

Last year, 38 papers were received. Of these, 27 were accepted, 16 of them for reading. The Section has always been a major source of material for The Institution's Ordinary Meetings, and in the past session four papers were so read. The international flavour of the Annual Lectures is remarkable. In the last few years, lecturers of renown have come from France, Germany, Holland, Italy, Russia, Sweden, Switzerland and the United States of America. The Section has had no important Conventions of its own, but its members regularly attend the world energy conferences and contribute notably to the deliberations. On several occasions the annual Summer Visits have been made to countries oversea, while the social events have been almost embarrassingly well attended.

The two named premiums, the Ferranti and the John Snell, are regularly awarded for papers of high merit, and on not a few occasions Section members have won major Institution premiums.

'Let us now praise . . .'

Since 1934 there has been a notable roll of Chairmen, with every facet of the Section's work represented. Many of these men—Fennell, Eve and Norris, for example—bear names well known and respected in the history of supply. Two of the Chairmen have achieved the Presidency. The academic representation has been small: another indication of the electronic lure, for regrettably few of the younger professoriate are heart and soul in 'heavy' electrical engineering. But even here the excellence of Prof. W. J. John (1947) has made up in quality the numerical deficiency.

The Supply Section, like the other three and indeed like The Institution as a whole, is an organization of individualists with a common aim and a strong comradeship. It advances because of the devoted, voluntary work of its members of past years. We can say about them, as about their forerunners of the pioneering days, 'We know better than they did, but it is because of them that we know'.

SETS conference 1958

THE Scottish Electrical Training Scheme held a one-day conference for all trainees on the 25th September 1958. This was a meeting similar to that in September 1957, the first year of SETS's operation.

In 1958 nearly 100 trainees attended, roughly double the number of last year; this is a measure of the increase in the size of the scheme in its second year of operation. Of the hundred, about 12 were graduates, about 70 were vacation students, and the remainder were young men who had been given a few weeks' industrial training before going to college this autumn.

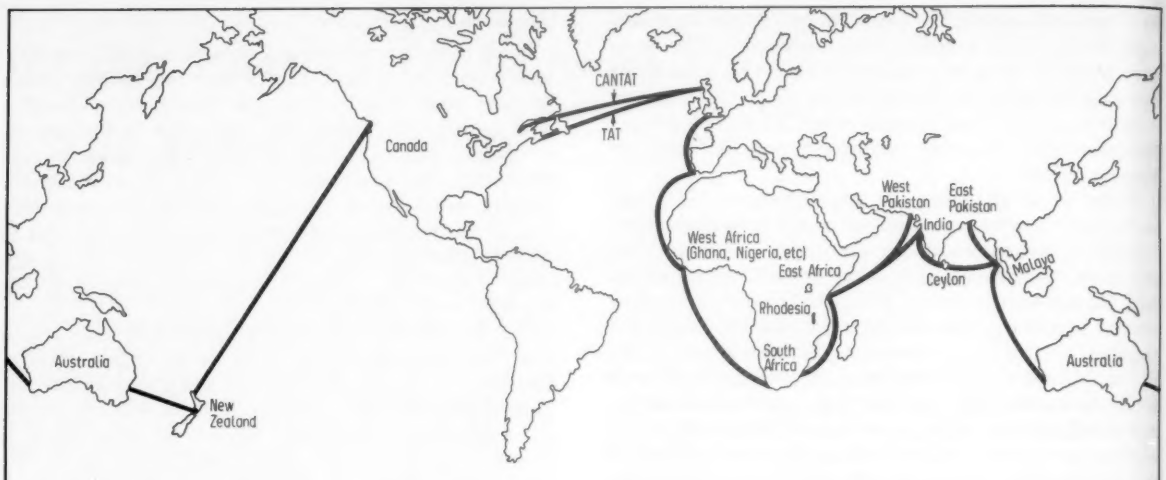
The conference took the form, as it did in 1957, of visits to the works of two of the members. Those attending were divided into two parties, each spending half the day with each member firm. Both parties assembled for the lunch, which was given by the directors to the trainees, in Paisley. B.B.C. and S.T.V. television reported the conference.

Top-of-the-tree target

At the lunch, Mr. K. W. Atchley, Chairman of SETS, welcomed the trainees, both the 'old hands' who joined in 1957 and the newcomers. R. B. Howie (graduate trainee, St. Andrews University) replied on behalf of the guests.

Mr. J. E. C. McCandlish, Organising Secretary of SETS, urged the trainees to realize that the good engineer, the man who was going to get to the top of the tree, was a man of wide interests. To become the chairman of a company or its managing director (and this should be their target) engineers had to be administrators and good citizens as well as first-class men professionally.

He also explained a new scheme for graduate training, starting this winter. There will be a series of one-day meetings of all graduates, partly to hear talks by experts on various matters of engineering and management interest, but more importantly to give the opportunity to graduates of having group discussions on these talks.



A Round-the-World Telephone Cable System for the Commonwealth

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It was announced from Montreal on the 24th September 1958 that the Commonwealth Trade and Economic Conference had approved in principle a proposal that a 'round-the-world' telephone cable should be constructed. It would link together the main countries forming the British Commonwealth of Nations.

The proposal had its origin in a detailed study by the Commonwealth Telecommunications Board, the results of which were reported to the Governments of Commonwealth countries. Subsequently, the technical and financial issues arising in connection with the proposal were examined at a conference of technical experts from all Commonwealth countries, which met in London during the early summer under the chairmanship of Sir Gordon Radley.

An immense amount has still to be done before a large and complex project of this kind can become a reality; but the report of the London Conference is, in effect, a blueprint for a system of world-wide telephone communication by cable which would provide facilities for all purposes—political, commercial and social—superior to any yet in existence.

Status of the project

Since the opening of a public telephone service across the North Atlantic in 1927, radio has played a major part in the development of world-wide communication. But no technical development can be foreseen which will enable radio to satisfy all likely requirements for growing telephone and telex traffic between Commonwealth countries. We must look to repeatered telephone cables to increase communication facilities on other world routes as they have recently done across the North Atlantic.

The present status of the project is that, the broad outline of the scheme having been approved at Montreal, it is for Commonwealth Governments to decide which parts of the system should be constructed and the time-table for doing so.

To a certain extent, the 'round-the-world' cable system has already begun to come into existence. The trans-atlantic telephone cable (TAT) brought into service in 1956 contained six circuits terminating in London and Montreal. United Kingdom–Canada communication will be further strengthened in 1961 by a new telephone cable (CANTAT), planned to provide 80 circuits between London and Montreal.* From this North Atlantic link the 'round-the-world' system may be expected to grow outwards—from the United Kingdom to the south via Gibraltar to South Africa, and from the western seaboard of Canada across the Pacific to New Zealand and Australia. The map shows the 'girdle round about the earth' completed.

* These are 3 kc/s circuits. The TAT circuits were 4 kc/s

Technical problems

There are two problems confronting telephone-cable engineers at the present time. One is to increase the frequency bandwidth which can be transmitted over a long transoceanic cable. The object is to provide cheaply for a large number of telephone circuits on routes of high traffic density, and ultimately for the transmission of television. That is the longer-term problem of the North Atlantic in particular. The other is to reduce the cost of telephone-cable communication on routes where the number of circuits required is comparatively small and the distances are very long.

CANTAT will be the first instance of the use of a single cable to provide both-way communication for telephone, telex, etc. over a long transoceanic route. To do so, instead of having separate cables for the two directions of transmission, means doubling the maximum frequency that has to be transmitted, more repeaters, and the inclusion in each repeater of directional filters to separate the two directions of transmission.

All this adds to the technical complexity and size of the repeaters. Their stowing away on shipboard and subsequent launching bring greater mechanical difficulties. These difficulties have been made easier by the British development of light-weight armourless cable for deep-sea work and of modified cable-laying machinery. Together these reduce the risk to the cable of laying large, rigid, steel repeater housings in deep water.

The cost of the 'round-the-world' cable system has been estimated on the assumption that both-way cables will be used, as for CANTAT. The use of twin cables, as for TAT in 1956, would be prohibitively expensive for the long distances of most intra-Commonwealth routes. Two cable diameters have been considered, 1in. and 0·8in. With repeaters spaced approximately 28 nautical miles apart, these cables would provide, respectively, 80 and 48 circuits using the special (3kc/s) channel equipment mentioned in the Foreword on p. 581.

Even so, the engineering of the system will present many technical problems. For example, the length of the link between Canada and Fanning Island (the nearest British territory in the Pacific) is just over 3400 nautical miles—half as long again as across the North Atlantic. It will therefore be useful to have the experience from the United Kingdom–Canada cable at an early stage in the enterprise.

The general benefit

During recent years there have been rapid advances in the design of submerged repeaters and submarine coaxial cables. Further advances may be expected, but these are unlikely to make a very considerable difference to the cost of a system of given traffic capacity. The cost of the 'round-the-world' system has been estimated at £88 million, including £13 million already expended or committed in respect of intra-Commonwealth circuits in TAT or CANTAT.

The Assistant Postmaster General, in closing the London Conference, used these words: 'The Commonwealth is a social, political and commercial organization, commanding, it is true, many machines, but it is based on the spirit of the men behind those machines. When we have completed the design sketched out on the map hanging on the wall of your conference room, the cables will be used for peaceful and useful developments, for the general benefit of ordinary men and women all over the world'. That is the hope of everyone associated with the project.

CORRESPONDENCE

TECHNOLOGICAL HUMANISM

From PROF. D. G. TUCKER,* D.SC., MEMBER

IT is to be hoped that the publication of Sir Eric Ashby's lecture in the September *Journal* (p. 478) will help electrical engineers to appreciate the importance of broadening the engineer's education and will encourage those responsible for technological education to 'do something about it'.

But the implication that nothing is being done at present is quite unjustified. Sir Eric states '. . . *some* English technical colleges have introduced *an element* of the humanities into their courses'.† It was clear, however, from the Easter 1958 conference at Cambridge‡ that *many* technical colleges have introduced *a great deal* of the humanities into their courses.

Sir Eric also says '. . . universities in Britain are not yet persuaded that the humanities are an essential ingredient in higher technological education. Many universities do indeed arrange opportunities for students to broaden their interests through voluntary attendance at lectures on art and music and the like. This is admirable, but it is a very different thing from recognizing certain humanistic studies as an integral part of a technologist's formal higher education.' For years, however, the Electrical Engineering Department of the University of Birmingham have made humanistic studies an integral part of the electrical engineer's education.* For the past two years, indeed, courses totalling about 72 hours of *scheduled* class time have been provided, and success in the

* Dr. Tucker is Professor of Electrical Engineering in the University of Birmingham

† Italics due to the present writer

‡ 'Liberal Studies in Technical Education', Board of Extra-Mural Studies, University of Cambridge

* D. G. TUCKER: 'Broader Education in a Technological Department', *Universities Quarterly*, November 1958

various examinations on these courses has been an essential part in the award of a degree.

The difficulty of finding time in the time-table for such courses is usually greatly exaggerated. The important thing in technological education is to *educate* the technologist. A great deal of the conventional technological courses has no great educational value and is unlikely to be used by the engineer in his later career. If he should want it later he ought to be able to learn it for himself; or he could attend a suitable postgraduate course, of which an encouraging number are now available. Thus a dispassionate review of syllabuses will readily show where room for broader education can be found.

Should broader education be provided for the university as a whole, or separately in each department? There seems to be need for effort at both levels. Open lectures on a wide range of topics are provided in all universities, but it is at the departmental level that efforts in broader education can be made to have the greatest effect.

In a large university, students inevitably attach their loyalty to their department, and therefore their departmental staff are in the strongest position to influence the students in their thoughts and plans. Thus in any broader education courses it is essential for the departmental staff to take a large share in the teaching and discussion. If these courses were left *entirely* to specialists from other departments or from outside the university, the students might be forgiven for doubting their relevance to the life of an engineer.

The courses in the Electrical Engineering Department at Birmingham follow remarkably closely the pattern recommended by Sir Eric. Informal discussion groups deal with such topics as the use of English (covering the students' own composition, speaking, and dramatic reading) and the influence of the industrial revolution on literature, society and institutions.

Formal lecture courses are given on design in engineering (to emphasize the breadth of interest in the engineer's life and the wide considerations of design) and on government and management in relation to the technologist (covering technologists in management, government research and its influence on industry, and innovation in small firms).

In the final undergraduate year, a comprehensive course* of about 44 lectures is given on the historical, sociological, economic and scientific background of technology, and on engineering production problems. In these courses as a whole, the Department's own staff provide about one-third of all the instruction, the remainder being provided by other departments in the Faculties of Science, Arts, and Commerce, and by outside speakers.

These courses are examined by means of vacation essays (in which a surprisingly high standard is reached by many students) and formal examinations. Some informal but prepared discussion meetings are organized by the students without help from the staff, and the standard reached is quite good. Impromptu discussions are, however, usually very poor. The courses are still experimental, and efforts are being made to improve them in many ways.

* D. A. Bell, 'Birmingham's Background', *Technology*, August 1958, p. 166

GEORG SIMON OHM AND HIS LAW

From H. T. G. MARSHALL, B.SC., ASSOCIATE MEMBER

I WAS most interested to read Mr. Hammond's article in the June *Journal*, p. 294, as I have just completed a translation of Lommel's book and the copy I used also had many pages uncut.

I think that Mr. Hammond is too unkind to Ohm: his personal sufferings are usually mentioned only as a circumstance to a particular experiment, and one must remember, in comparing him with Faraday, that Ohm lacked that one important blessing that Faraday received, patronage. In spite of this, two scientific laws carry his name; and had he had the means he would no doubt have completed his theoretical forecast of Faraday's laws of electrolysis (published six years before Faraday) by experimental proof.

Rollo Appleyard, in his 'Pioneers of Electrical Communication' (London, 1930) confirms Ohm's date of birth as 1789 and refers to an entry in the parish register at Erlangen. His short article on Ohm is very illuminating (a copy is in the Institution Library).

I am indebted to Mr. Perrin for his interesting information on the controversy about Ohm's law reported some 45 years ago. Mr. Hammond quotes Ohm's first attempt correctly but omits to refer to his first correct law (given on p. 25 of Lommel): $X = \frac{a}{b + x}$, where X is the strength of magnetic action (due to the current) of a conductor of length x, and a and b are constants dependent on the exciting force, and the resistance of the remainder of the circuit.

The equation was derived from the results of his thermo-electric experiment. He refers to it as a law on the same page, and it is this law which he continually applies in the remainder of his electrical papers. He never called it Ohm's law, but there is little doubt that it is the true parent of our modern $I = \frac{V}{R}$.

From H. BERRING*

MR. P. HAMMOND's article in the June *Journal*, p. 294, brought to mind an experience of several years ago when I became the victim of some good-natured 'joshing' about Ohm's law and, 'in revenge', wrote an article about it in my company's house organ.

I have since changed my mind about the inadequacy of Ohm's sources of electric current, particularly in the light of what Ampère, Faraday and others were able to do several years earlier. It would, indeed, seem obvious that Ohm did not concern himself much with the state of the art. In fact, he says as much in the introduction to his monograph of 1827, where he explains his bitterness, hardships and the limitations of the conditions in which he worked. This apparent isolation, however, would not seem to lessen the fundamental significance of Ohm's accomplishment.

It may please Mr. Hammond to note that someone, at least, did cut the pages of Lommel's book and derived pleasure from its contents.

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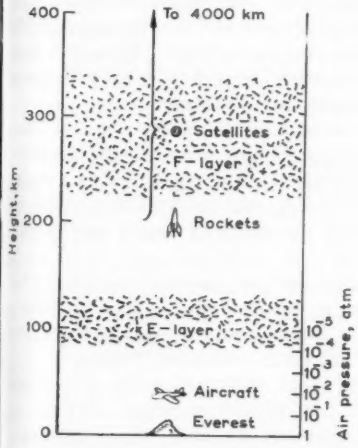
INFORMATION BY RADIO FROM THE SATELLITES

Radio waves emitted from artificial earth-satellites can be used to make deductions about the satellites' positions and about the ionosphere through which the waves travel. In this article, based on the lecture entitled 'Radio Observations on Artificial Satellites' which the author delivered at the Ordinary Meeting on the 10th April, an account is given of the results obtained so far, mainly with the first Russian satellite, 1957α. Mr. Ratcliffe is at the Cavendish Laboratory, University of Cambridge. The lecture was given again, to the South Midland Centre, on the 13th October.

J. A. RATCLIFFE, O.B.E., M.A., F.R.S., MEMBER

We live at the bottom of an ocean of air. We were all taught that at school, but it is rather difficult to realize the magnitude of this ocean. Elementary teaching tells us that it is equivalent to about 30 ft of water. Imagine living at the bottom of a swimming-bath 6 ft deep, then under 30 ft of water, and consider the questions we would be asking. What is it like above the water? Where does the light come from, and what was it like before passing through the water? How far upwards does the water extend? How does its pressure vary with depth? We have the same sort of problems at the bottom of our ocean of air, problems which have been interesting people for a very long time, and rather intensively for the last 30 or 40 years.

There are two ways of tackling such problems: indirectly and directly. The indirect method has been chiefly used up to the present, whereby radio waves received on reflection from the ionosphere are used to tell us what the upper atmosphere is like, what the sun's radiation is like, and how it changes when the sun is disturbed. Only recently has it been possible to use the direct method of sending up rockets, and later satellites, to act as exploring laboratories. Fig. 1 shows schematically what happens at different heights in the atmosphere.



1 *Experimental exploration of the upper atmosphere*
The two main ionospheric layers are indicated by shading

The purpose of artificial satellites is to have an experimental laboratory and radio transmitter which stays at a height greater than about 150 km for a long time, and moves so that it covers a large part of the earth's surface repeatedly. Several satellites have already been launched, with the characteristics shown in Table 1.

A satellite under the attraction of the earth moves in an orbit which is very nearly an ellipse, with the centre of the earth as one focus. If the earth were quite symmetrical the plane of the ellipse would remain in the same absolute direction and would follow the earth round the sun. The time of rotation in the orbit depends on the size of the ellipse: it is of the order of $1\frac{1}{2}$ hours if the satellite is at a height of a few hundred kilometres. The earth rotates, on its own axis, inside this orbit once in 24 hours. An observer at a given place on the earth therefore moves relative to the orbit as illustrated in Fig. 2. He is carried round the line ABCD once in 24 hours, while the satellite goes round its orbit PQR once in $1\frac{1}{2}$ hours. When the observer is near B the satellite will pass over or near him on a few north-going tracks, and then later, when he reaches D, it will pass over or near him on a few south-going tracks. Whether these transits occur by day or by night depends on the position of the sun with reference to the plane of the orbit, and this changes with the time of year.* Only the Russian satellites have, so far, passed over this country.

The radio waves emitted from the satellite can be used for three different purposes: for determining the orbit; for finding out about the ionosphere through which they travel; and for sending back, by telemetry, the information gained by the automatic measuring equipment carried in the satellite.

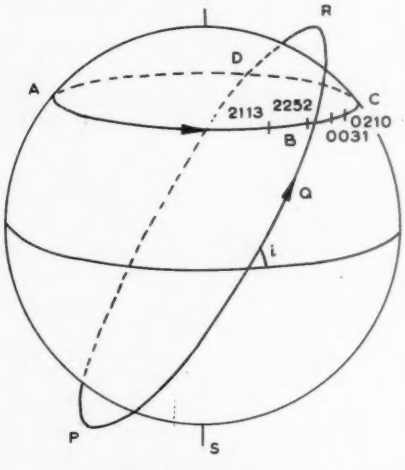
* It will also change for other reasons which are discussed later

Table 1. Artificial satellites

Maker's name	Astronomer's name	Date of launching	Shape and size	Initial orbit			Principal experiments	Radio frequency
				Period	Perigee	Apogee		
				min	km	km		
Sputnik I ..	1957α	Oct. 4, 1957	Sphere 23 in. dia.	96·2	200	900	Ionospheric studies Air density	40·002 Mc/s 20·005 Mc/s
Sputnik II ..	1957β	Nov. 3, 1957	Cone 30 ft long	103·7	270	1700	Ionospheric studies Living condition in space Cosmic rays Solar X-rays	40·002 Mc/s 20·005 Mc/s
Explorer I ..	1958α	Jan. 31, 1958	Tube 80 × 6 in.	114	330	2500	Cosmic rays Micrometeorites	108 Mc/s 108·03 Mc/s
Vanguard I ..	1958β	Mar. 17, 1958	Sphere 6·4 in. dia.	134	650	4000	Air density Testing solar cells	108 Mc/s 108·03 Mc/s
Explorer III ..	1958γ	Mar. 26, 1958	Tube 80 × 6 in.	115·7	200	2800	Cosmic rays Meteors	108 Mc/s (tape recorder) 108·03 Mc/s (tracking)

Determining the Orbit

Elaborations of the ordinary methods of direction and elevation finding lead to measurements of the angular position and its variation with time. It is interesting to see in principle how information about the track is derivable from the observations. In one arrangement, for example, an interferometer is used, consisting of two aerials separated by several wavelengths and connected to a recorder in such a way that the output oscillates sinusoidally as the difference between the paths of the waves from the satellite to the two aerials varies. When the record passes through a zero the path difference is known to be an odd number of half-wavelengths, so that the satellite is known to be on one of a series of confocal hyperboloids of revolution with the two aerials as foci. Successive zeros on the record correspond to passages of the satellite across successive hyperboloids. It is then a matter of geometry to discover what orbit would correspond to the time intervals observed between these crossings.



2 *The orbit of 1957α in relation to Cambridge*
The times show the approximate positions of Cambridge during successive evening transits

Another method of radio observation makes use of the Doppler effect. As a satellite passes close to an observer the frequency of the waves received from it alters as shown in Fig. 3. The limiting frequencies, at the two ends of the record, represent the Doppler shifts when the satellite is moving straight towards, and straight away from, the observer, and from the difference between them the velocity can be determined.

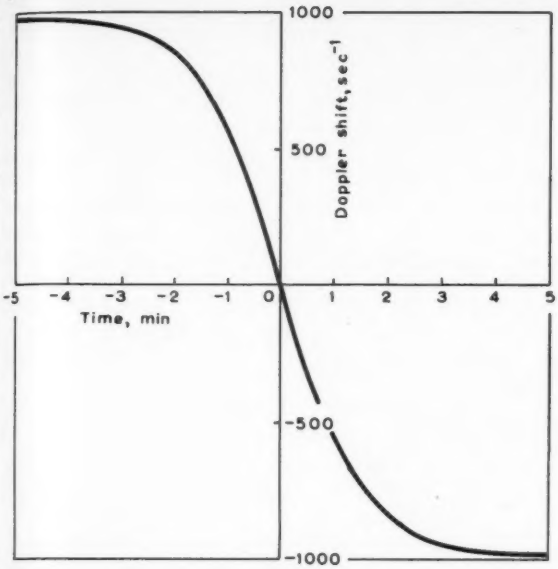
The shape of the curve depends on how quickly the line-of-sight velocity changes and hence on the distance of closest approach. If this distance from two or more places is determined for the same track, it is possible to deduce the position of the track in space, and hence the orbit.

It is equally satisfactory to use one observing point and make observations on successive transits, between which the observing point is known to have moved to a new position in virtue of the earth's rotation (Fig. 4).

The tracks deduced from radio observations are not sufficiently accurate for many purposes, and it is necessary to supplement them with more accurate visual or radar observations, but they are useful to indicate where the search should be conducted with the more accurate device.

Deductions from the Nature of the Orbit

Once an orbit has been obtained, either by the less-accurate radio or the more-accurate optical method, some interesting results can be deduced. To understand



3 *Typical Doppler curve for 1957α*

these a few simple facts about orbits must be explained by reference to Fig. 5. If a satellite is launched horizontally from a point P it will move in a circle only if it has the right speed. If its speed is too great it will travel in an ellipse, whose farthest point A (apogee) is further away and whose nearest point (perigee) is at P; while if it is launched too slowly P will be the apogee and either the perigee will be at a point such as R or the satellite will hit the earth. Once the orbit has been determined the time period of revolution is known, since one of Kepler's laws of planetary motion is that the square of the periodic time is proportional to the cube of the major axis.

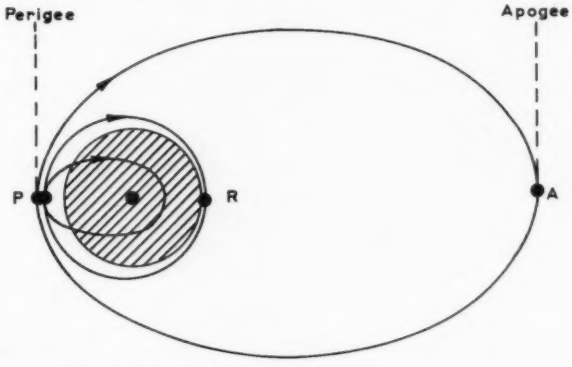
Now, although the earth's atmosphere has very low density at the height we are discussing, it is not quite negligible, and it opposes the motion with a small but appreciable force. This force is quite simply calculable in terms of the mass of air encountered by the satellite in unit time. Because the density is greatest at the perigee, the force is mainly experienced there, so that in each rotation as the satellite passes the point P in Fig. 5 it is slowed down slightly. But the result of a slowing down at P has already been seen to be a shortening of the major axis, a decrease of the apogee distance, and a decrease of the periodic time. The apogee continues to move inwards until, after several revolutions, the apogee and perigee distances are nearly the same and the orbit is nearly circular.

Now if, in an orbit which is nearly circular, the satellite is impeded by air resistance, it is caused to spiral inwards slowly towards the earth, and the velocity *increases*. It is at first sight paradoxical that a *resistive* force can cause the velocity to increase, but it can be seen, from a simple calculation, that the work done by gravity in accelerating the satellite as it slowly spirals in proves to be just twice as large as the work done by the air friction in decelerating it. Although the kinetic energy increases as the satellite falls in, its potential energy decreases twice as much, so that on the whole it loses energy.

From observations of the periodic time it is possible to calculate the force resisting the motion. It would be of great importance if, from this force, an estimate could be made of the air density. For a simple shape, such as a sphere, it is possible to make this estimate, and that is why two of the early satellites listed in Table 1 were made spherical.

4 *Determining the position of a track in space by observing its distance of nearest approach on successive transits when the observing station is at A and B*

The figure is to scale for 1957α observed from Cambridge, and the accuracy is indicated by the shading



5 *A satellite's orbit*

Previously there were two conflicting theories of the density of the atmosphere at heights of about 300 km, both compatible with the results of experiments of the indirect type, but suggesting densities which differed by a factor of about 10. It is already clear, from the satellite results, that the one giving the smaller density is the more nearly correct.

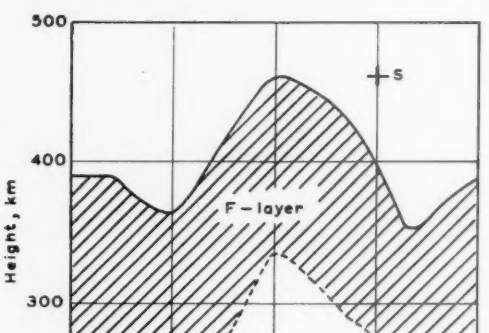
So far, it has been supposed, for simplicity, that the earth is spherically symmetrical. In fact, its gravitational field is better described by saying that it has approximately the symmetry of an oblate spheroid. The ellipsoidal form of the earth causes the whole plane of the

orbit to precess slowly, at the rate of about 3° per day, so that it no longer remains in the same absolute direction in space. As a result, the local time at which transits pass nearly overhead changes, and this change turns out to be more rapid than the similar change, previously referred to, which would occur as the earth moved round the sun during the year.

A second result of the departure from spherical symmetry is that the major axis of the ellipse rotates slowly in the plane of the ellipse, so that the apogee and perigee move round.

Information about the Ionosphere

As the wave travels from the satellite to the ground through the ionosphere, its velocity alters from point to point and it is refracted. These effects become more marked at the lower radio frequencies, and for purposes of ionospheric investigation it is fortunate that the first two Russian satellites (1957 α and β) were equipped with transmitters radiating at 20 and 40 Mc/s; indeed, it is probable that these frequencies were chosen because they would be of value for exploring the ionosphere. The frequency of 108 Mc/s used in the American satellites is little affected by the ionosphere: it can therefore be used for fairly accurate position-finding, but is not of much use for ionospheric investigations.



6 *Relation of morning and evening transits of 1957α over England to the F-layer*

———— Height of the peak of ionization
– – – – – Minimum virtual height of the layer

Observations of the waves received on 20 and 40 Mc/s can be used to make deductions about the total number of electrons in a column of unit cross-section extending from the ground to the height of the satellite. These results can be compared with what has been found out about the ionosphere by the usual technique of emitting pulses of radio waves from a transmitter on the ground and observing them after reflection from the ionosphere. Experiments with ground transmitters can provide information only about the ionosphere below the peak of the F-layer; the value of observations with satellites is that they can provide information about the electron content above the peak. Experiments made by several different workers on 1957α have shown the orders of magnitude of some of the quantities involved and have indicated that, with more accurate experiments on future satellites, it should be possible to derive more detailed information. The most successful results have been obtained by observing the Doppler effect, and the fading caused by ionospheric irregularities and by the Faraday effect. These three types of experiment will be discussed separately.

The Doppler Effect

In free space the Doppler shift of frequency is proportional to the radio frequency itself, so that if the variations observed in the received frequencies at 20 and 40 Mc/s were plotted against time, each would give a curve like that of Fig. 3, but with the frequency scales in the ratio 2: 1.

The presence of the ionosphere alters these Doppler shifts slightly, in the following way. The earth's magnetic field causes the ionosphere to behave as a birefringent medium, so that the path of a ray from a satellite to the ground is somewhat difficult to calculate and is different for the ordinary and the extraordinary waves. As the satellite moves, the position and length of the ray change and the phase of the arriving wave alters correspondingly. This continuous alteration of phase is equivalent to a change of frequency; it is, in fact, the Doppler effect. Detailed calculation shows how far the Doppler shift calculated in this way differs from that expected in free space.

If curves like those of Fig. 3 are plotted for 20 and 40 Mc/s, with the frequency scale doubled for the 40 Mc/s one, then the difference between the two curves can be used to estimate the total electron content in a unit column extending up to the height of the satellite.

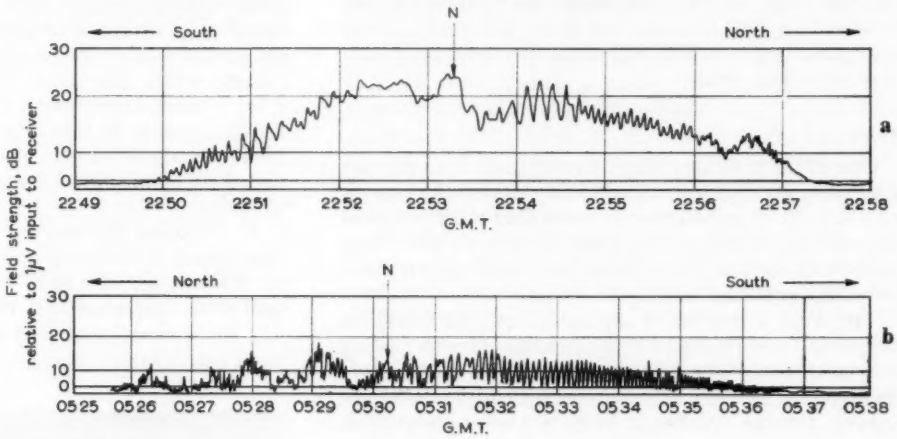
If observations are to be useful for making this estimate the frequency must be accurate to about 1 c/s and the timing to about 0·1 sec. Only a few of the early observations approached that accuracy, but with proper precautions it should be possible to achieve it in future.

Fig. 6 shows how the position of the first Russian satellite was related to the ionospheric layers. When the satellite was below the ionization, in the evening, the Doppler measurements agreed quite closely with the result expected for free space. In the morning, when the satellite was above the peak of the F-layer, these quantities were no longer equal. From their lack of equality it was possible to estimate the total electron content in a unit column extending from the ground to the height of the satellite, and to compare it with the corresponding quantity up to the height of the peak of the F-layer as determined from normal ionospheric observations.

The results so far obtained indicate fairly clearly that the electron density above the peak falls off rather slowly. The precise gradient should be deducible from more accurate observations in the future, and it will be particularly interesting to see how it varies with time of day, season, and solar cycle, and when there is an ionospheric storm in progress.

Ionospheric Irregularities

The wave received at the ground from the satellite 1957α was found to fade in a rather complicated manner.



7 *Fading of waves received from 1957α*
a Evening b Morning (Compare with position of satellite shown in Fig. 6)

One type of fading was much faster and less regular than the others and occurred only when the satellite was in the northern part of its track, about latitude 65° N., and was at heights greater than about 270 km. Fig. 7 shows the fading on a low transit (evening) and on a high transit (morning) and illustrates how the rapid fading occurred only at the northern end of the higher transit.

It is believed that this rapid fading occurred when the satellite moved through, or above, a region in which there were irregularities in the electron distribution. The size of these irregularities can be determined from the speed of the satellite and the speed of the fading; it is about 5 km. The irregularities are probably the same as those which produce increased scintillations of radio stars when they are observed through the northern ionosphere.

It is possible that weaker irregularities, of different origin, may be the cause of some irregular 'kinks' in the records of the Doppler shifts. These kinks appear to be real and not the result of experimental error, and although they are not yet understood properly there is little doubt that they will ultimately reveal important knowledge about the ionosphere.

The Faraday Effect

Faraday discovered that if a beam of linearly polarized light is passed through a block of glass along the direction of a superimposed magnetic field it emerges with its plane of polarization rotated. This is called the 'magneto-optical Faraday effect'; it has been explained as follows.

The glass, in the presence of the magnetic field, splits the incident wave into two characteristic circularly polarized waves with opposite senses of rotation, which then travel with different velocities. On emerging from the glass these combine to produce a linear polarization in which the direction of vibration has been rotated from its original plane through an angle which depends on the thickness of the glass. A similar phenomenon occurs when a radio wave traverses the ionosphere in the presence of the earth's magnetic field; then the angle of rotation depends both on the length of the path and on the distribution of electrons along it, in such a way that the total number of electrons in a tube of unit cross-section drawn along the path is the determining factor.

If the satellite emits a linearly polarized wave, the total number of electrons between it and the ground will change as it moves, and the plane of polarization of the wave at the ground will rotate steadily. If the wave is received on a linear aerial the recorded amplitude will vary approximately sinusoidally. This variation has been observed and has been shown to correspond to a rotation of the plane of polarization by comparing the records made on two linear aerials oriented at right angles.

Theory shows that the rate of fading caused by this rotation is inversely proportional to the square of the radio-wave frequency, so that it would be four times as rapid at 20 Mc/s as at 40 Mc/s. When records at the two frequencies are compared it is found that, although this relation is not obeyed in its simple form, it is obeyed quite well if a fixed rate of fading, n per minute, is first subtracted from all the records obtained on both frequencies.

This is thought to imply that n represents the fading caused by a rotation of the satellite as it travels, and for 1957α it corresponded to about 13 rotations per

minute. After subtracting this quantity, the Faraday fading can be studied. This leads to an independent estimate of the total electron content in a unit column of the ionosphere which is consistent with that deduced from the Doppler measurements.

In describing the Doppler shift attention was restricted to one of the two characteristic waves. The Doppler shift of the other would be different, and if they were both received together on a linear aerial they would produce beats at the difference frequency. This is precisely the Faraday effect, thought of in a slightly different way. The two phenomena are produced by the same causes but are observed quite differently: some interesting points will emerge when they have both been studied in finer detail.

Telemetry

One of the most important uses of radio is to provide a telemetering signal which will allow us to make records on the earth of measurements conducted in the elevated laboratory. Of the measurements known to have been made with the first few satellites (see Table 1), two are of particular relevance here.

The daily variations of the earth's magnetic field are supposed to be produced by quite large currents flowing overhead in the ionosphere, driven by the tidal movement of the air which constitutes an enormous 'atmospheric dynamo'. Although much is known about these currents and their distribution over the earth, their height is not known nor is it easily measurable. It is hoped that measurements made in satellites will enable it to be determined.

The other measurements are concerned with exploring the nature of the sun's radiation before any of it becomes absorbed in the atmosphere, and of particular interest are the changes in the radiation occurring at times when there is much solar activity and the ionosphere is disturbed.

Summary

The radio waves emitted from a satellite can be used to determine its approximate orbit, and from the changes in this orbit deductions can be made about the density of the highest parts of the ionosphere. Studies of the Doppler-shifted frequency, of the polarization, and of the fading of the waves, can be used to investigate the ionosphere. It is found that the electron density above the peak of the F-layer falls off rather slowly and that there are irregularities in the electron density at heights above about 250 km and at latitudes greater than about 65° N.

References

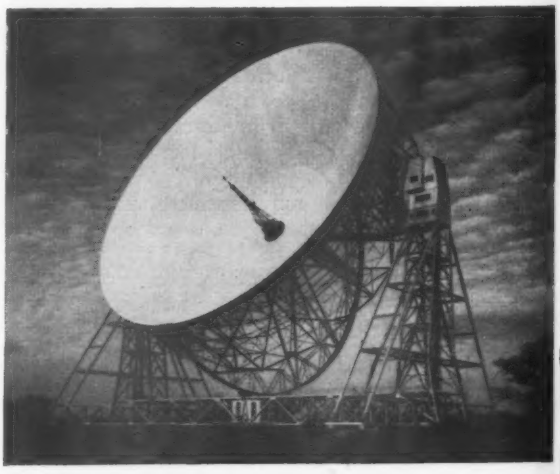
1 'Radio Observations on the Russian Satellites', *Proceedings I.E.E.*, 1958, **105 B**, p. 81

2 MASSEY, H. S. W., and BOYD, R. L. F.: 'Scientific Observations of the Artificial Earth Satellites and their Analysis', *Nature*, 1958, **181**, p. 78

'The Inquisitive Giant'

A NEW 28-minute film about the design and construction of the Jodrell Bank radio telescope is currently available in the United Kingdom. This film, whose English title is 'The Inquisitive Giant', was produced by the Central Office of Information primarily for distribution oversea and is already obtainable abroad through British Information Services, with commentaries in English and other languages. It may be hired in the United Kingdom at the rate of 15s. for the first day (16 mm print) and 3s. for each additional day, the initial charge recurring every eighth day; and purchased outright for £23 7s. 6d. (16 mm print) and £41 5s. (35 mm print). Prints are obtainable from the Central Film Library, Government Building, Bromyard Avenue, Acton, London W.3; the Scottish Central Film Library, 16–17 Woodside Terrace, Charing Cross, Glasgow C.3; and the Central Film Library of Wales, 42 Park Place, Cardiff.

A 14-minute film in the C.O.I.'s 'Televiews' series—'The Giant Radio Telescope'—forms a useful prologue to 'The Inquisitive Giant' and is also suitable for projection on larger screens. Prints may be purchased for £12 15s. (16 mm print) and £22 10s. (35 mm print) from the Central Film Library.



The Jodrell Bank radio telescope is constructed of steel and weighs 2000 tons. It revolves on huge bogies and carries a giant reflector bowl 250 ft in diameter, the bowl itself weighing 750 tons and rotating on two trunnions 180 ft above the ground. The construction of the telescope required the solution of a number of civil-engineering and climatic problems. Part of the bowl's tilting mechanism is made from the rack of the gun turret of the battleship H.M.S. *Royal Sovereign*. A special climatic problem was concerned with the strains imposed when snow filled the bowl (which can, in fact, be completely inverted).

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A Flat Television Tube

During the last four years a team of workers in the Department of Electrical Engineering, Imperial College of Science and Technology, have been carrying out research on a flat, thin television tube for monochrome and for colour. Although this development, under the auspices of the National Research and Development Corporation, is not yet complete, an interim report, on which this article is based, was made in a paper (2661) entitled 'A New Cathode-Ray Tube for Monochrome and Colour Television', by Prof. Gabor, P. R. Stuart, Ph.D., and P. G. Kalman, Ph.D., which was read before the Radio and Telecommunication Section on the 14th May 1958 (see July Journal, p. 411).

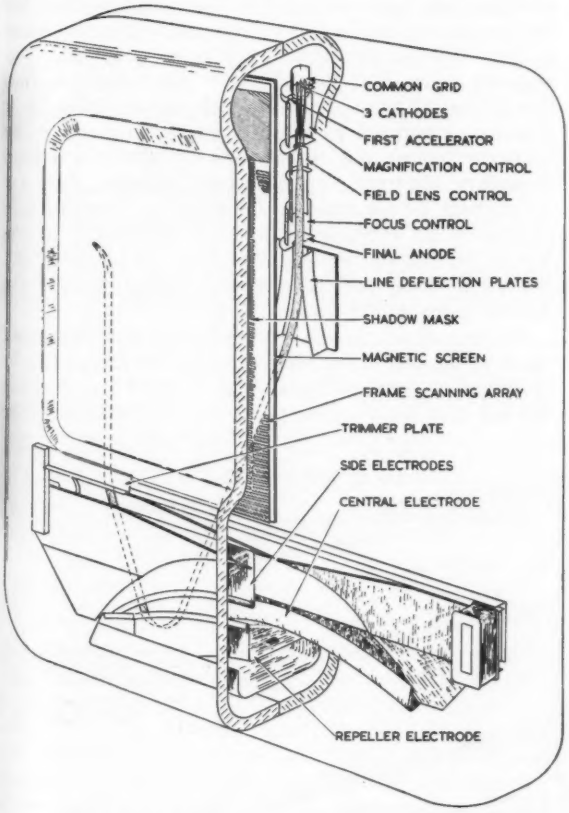
The paper was presented again, to the Rugby Sub-Centre, on the 11th November 1958. Further readings have been arranged as follows: the N.E. Radio and Measurement Group on the 17th November; the Sheffield Sub-Centre on the 17th December; the S.W. Scotland Sub-Centre on the 6th January 1959; and the S.E. Scotland Sub-Centre on the 7th January 1959. Prof. Gabor now holds the chair of Applied Electron Physics in Imperial College.

Prof. D. GABOR, DR.ING., F.R.S., MEMBER

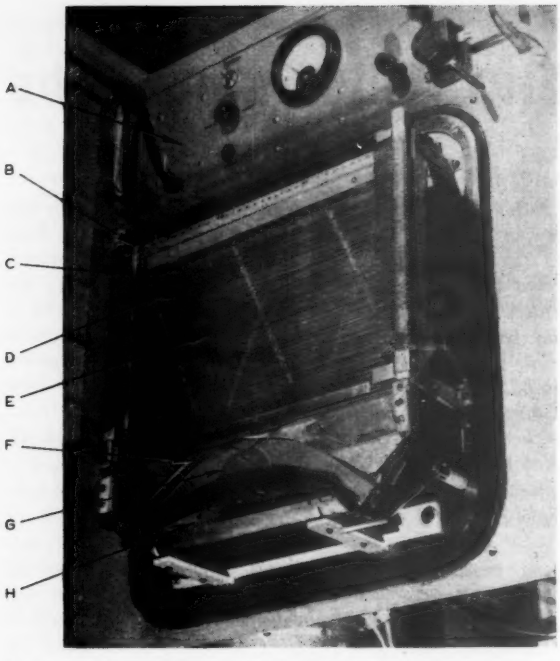
THE DEVELOPMENT WORK BEING CARRIED OUT AT Imperial College on a flat television tube is not complete, but it has reached a stage at which all the numerous electron-optical and technological problems have received satisfactory, if not final, solutions which could be tested singly and partly in combination. By its very nature, a development of this type cannot be wholly completed in an academic laboratory, but only in industry.

General design of the tube

In conventional cathode-ray tubes the beam approaches the screen in a straight line, like a pencil pivoted at its end. In the new tube, shown schematically in Fig. 1, the beam is folded over on itself and runs for most of its length parallel to the picture screen, bending towards it only on the last short section of its trajectory. The tube is essentially a flat box, with a depth of about 2in. inside for a screen of 12in. diagonal. It is divided in depth by a metal base-plate, which carries all the electrode structures and which acts also as a magnetic screen. The electron gun is mounted behind this partition, near the top, and launches the electron beam (in colour tubes 3 beams) vertically downwards. The beam passes through a pair of line- or X-deflection plates, so that it swings like a pendulum parallel to the base-plate in the rhythm of the line scan, with an angular excursion of about $\pm 15°$. The gun and the X-deflectors are more or less conventional, but the next electron-optical element, the reversing lens, is essentially novel. Its purpose is to turn the fan of cathode rays by 180° into another vertical plane, at the same time multiplying their deflection angles by a factor of about 4, so that they now proceed upwards with a swing of nearly $\pm 60°$ to the vertical. Owing to this large divergence, the sweep covers the



1 *The Gabor–N.R.D.C. colour-television tube: all-glass version*



2 *Inner electrode system of an experimental tube*

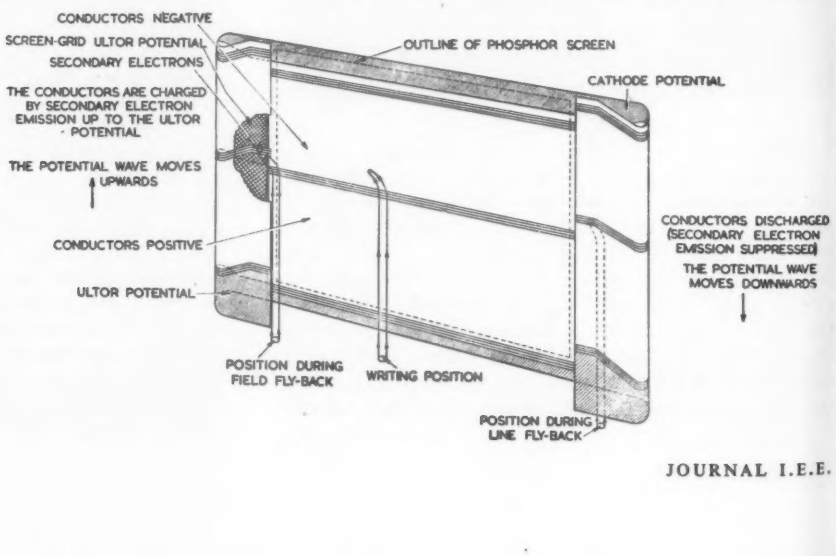
A Vacuum gauge B Screen grid to remove secondary electrons C Fly-back loop of scanning array, fitted with good secondary emitters D Scanning-array conductors E Screen area F Magnetic collimator pole-pieces G Reversing-lens positive electrode H Reversing-lens negative electrode (repeller)

whole horizontal width of the picture screen at a level only a few inches above the lowest point of the trajectories. At this level the rays are collimated, i.e. turned into a vertical direction, by a powerful magnetic-lens system called the collimator. From here the beam proceeds vertically into the narrow space behind the picture screen and enters another vertical plane parallel to the screen, which contains the scanning array. This is an array of a large number (about 100) of thin horizontal conducting strips, insulated from one another and not connected with anything. They are charged and discharged by the electron beam itself. The tube demonstrated on the 14th May 1958 is shown in Fig. 2.

The self-scanning principle

The principle of self-scanning is explained in Fig. 3. Assume that up to the four conductors shown near the middle of the array all conductors are at the highest positive potential (called the 'ultor' potential), while above these they are at a low potential, at or near that of the cathode. As the picture screen itself is at ultor potential, there is no field between this and the array below the group of four conductors, while above it there is a strong field deflecting the beam towards the screen, and at the same time, as will be explained later, sharply focusing it. Once such a field is established it can remain unaltered for a long time so long as the beam swings opposite the screen, because the conductors are insulated and not touched by the beam. At the right and left ends, however, the array is bent into U-shaped loops, so that the array conductors are now facing the beam. They are here displaced upwards by such a distance that just that group of, say four, conductors in which the potential changes from negative to positive are contacted by the electron beam. At the end of every line scan the beam is arrested for a short time in the loop at the right, and negative charge is deposited on the conductors, so that the discharge wave moves a little downwards, by a distance determined by the capacitance to earth of the array conductors and by the beam current. In this loop secondary electrons cannot escape because they are driven back by the negative charge at the opposing side of the U. By applying an appropriate current to the gun in the interval between the end of the line scan and the line fly-back, the line is made to sweep down at the desired speed, in the rhythm of the frame scan.

At the end of a frame scan the beam must be raised again to the top of the picture; hence the array must be recharged to ultor potential. This is done by arresting the line scan for a moment and making the beam move


CONDUCTORS NEGATIVE
SCREEN-GRID ULTOR POTENTIAL
SECONDARY ELECTRONS
THE CONDUCTORS ARE CHARGED BY SECONDARY ELECTRON EMISSION UP TO THE ULTOR POTENTIAL
THE POTENTIAL WAVE MOVES UPWARDS
CONDUCTORS POSITIVE
ULTOR POTENTIAL
OUTLINE OF PHOSPHOR SCREEN
CATHODE POTENTIAL
CONDUCTORS DISCHARGED (SECONDARY ELECTRON EMISSION SUPPRESSED)
THE POTENTIAL WAVE MOVES DOWNWARDS
POSITION DURING FIELD FLY-BACK
WRITING POSITION
POSITION DURING LINE FLY-BACK

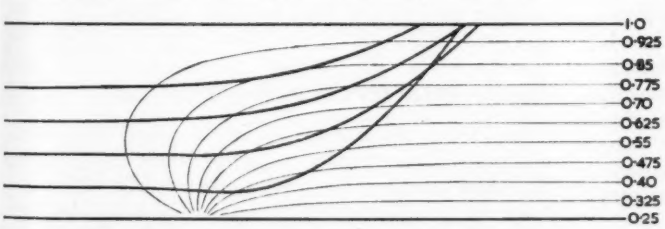
3 *The principle of self-scanning*

into the loop at the left. This is similar to the other, but with the differences that it contains a screen grid at ultor potential and that the array conductors are made of or coated with a good secondary emitter. If the secondary yield exceeds unity, more secondary electrons are drawn away from the array than there are primary electrons landing on it; hence the effect is the same as if it received a positive current. The array potential will therefore keep rising, and the beam will climb up in the loop, until the whole array has attained ultor potential and the beam has reached the top. It is now only necessary to start the line scan again in order to repeat the whole cycle, because on top of the array there is a conducting strip permanently at cathode potential, which, in conjunction with the positively-charged array conductors below it, pre-shapes the discharge wave, which immediately starts running downwards as soon as the beam has reached the loop at the right.

Two features of this very novel process might appear doubtful, had they not been confirmed by experiment. One is that the scanning wave can run down undistorted, e.g. with a transition region of, say, four conductors, from the top to the bottom. The other is that a secondary yield well exceeding unity can rightly be expected at the high electron energies of 10–20 keV which are used in modern television sets. This was, in fact, achieved with certain suitable materials, owing to the favourable circumstance that the incidence of the primary electrons is so oblique that the secondary yield substantially exceeds the usually quoted figures, which are valid at perpendicular incidence.

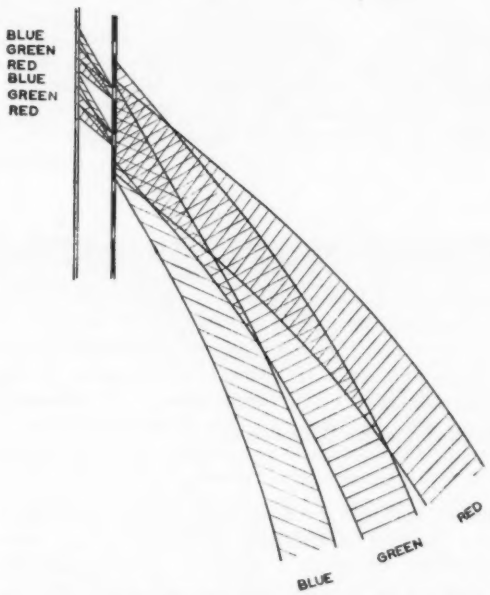
Application to colour television

The importance of the self-scanning principle lies in the fact that there is no need to provide any outer circuits for the frame scan, nor is it necessary to provide leads through the vacuum envelope for the array conductors.



4 *Focusing of parallel electron trajectories between the equipotential phosphor screen and the scanning array*

This would present great difficulties, in view of their number, which must be large if the tube is to be used for colour television. The reason for this can be understood from Fig. 4, which illustrates the focusing of a thick electron beam by the field between the array and the picture screen. It can be seen that a beam occupying about one-third of the available space is focused into a very narrow zone; moreover, it is focused with a convergence angle of the order of 30°, which is an exceptionally wide angle in electron optics. This phenomenon makes it possible to apply the new tube to colour television, using the well known shadow-mask principle but avoiding its difficulties, which in conventional colour tubes could be overcome only by



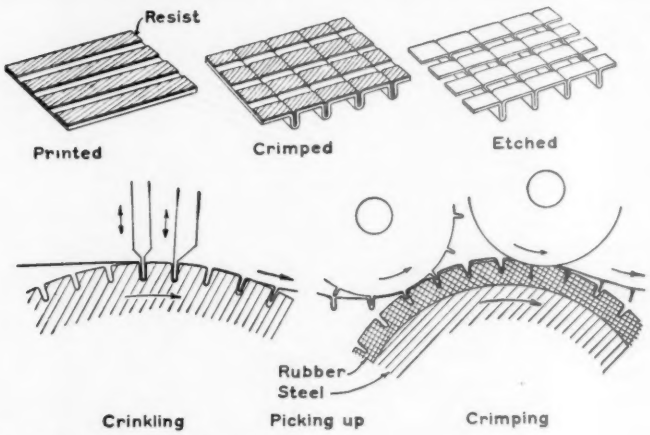
5 *Colour production by means of a shadow-mask in the flat tube*

astounding feats of precision manufacture. As shown in Fig. 5, the combination of large convergence angles with the oblique incidence results in the new tube in complete colour separation at a spacing of the shadow-mask from the colour screen which is equal to or even slightly less than the length of a colour cycle on the screen. For example, if there are 50 colour cycles per inch (i.e. 150 lines of differently coloured phosphors altogether), this spacing is only about 0·018 in., while in conventional tubes it is of the order of 0·5 in. Similarly, whereas in conventional tubes the shadow-mask and the colour screen must be made separately but with accurately corresponding patterns and held in perfect register, in the new tube it has become possible for the first time to fix the shadow-mask directly on the screen.

The shadow-mask

The manufacture of the new type of shadow-mask, illustrated in Fig. 6, is simple and makes possible considerably finer rasters than hitherto used. A metal foil, about 0·001 in. thick, is printed with a fine raster of parallel strips of acid-insoluble resist. This is then pleated with sharp folds in the machine, forming ribs,

say 0·018in. high, which act as spacers. After etching, the shadow-mask is cemented on the glass screen with a suitable adhesive, preferably one which retains a little tackiness on its surface even after it has sufficiently

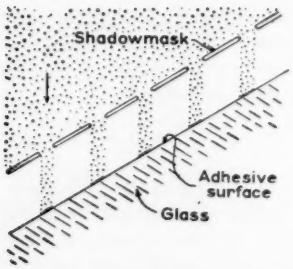


6 *Manufacture of the shadow-mask*

hardened to hold the mask securely to the glass plate. Phosphor powders of the three basic colours are now applied, simply by letting a cloud of finely ground and evenly distributed powder descend vertically through stagnant air onto the slightly adhesive glass surface (Fig. 7). This simple method can be applied only because of the very small spacing between mask and screen. It results in very sharply delineated colour-phosphor strips, which can be made as narrow as 0·005in.

Development problems

In order to exploit the potentialities of the flat colour tube it was first necessary to solve several rather intricate electron-optical problems. As may be seen from Figs. 4 and 5, in order to achieve colour purity it is necessary to guide the three colour beams exactly vertically, in three equidistant planes. This is achieved by the combination of the electrostatic reversing lens and the magnetic collimator, which together have to satisfy nine electron-optical conditions. This explains the difficulty of the development work, which was carried out semi-empirically, as the conditions were too complicated for *a priori* mathematical design, and which took about three years. It may be asked whether the somewhat complicated electrode and pole-piece shapes with which the solution was achieved will not impose too narrow limits on their manufacture, i.e. whether the need for precision, which is driven out of the region between the shadow-mask and the screen, will not return via the electrode system? It was found indeed that if one wanted to operate the reversing lens with *two* potentials only (cathode and ultor potentials), the tolerances on certain dimensions would be too stringent. Fortunately, all errors which may arise from slightly wrong mechanical dimensions can be eliminated by not more than five small electrical corrections, i.e. by 'trimming' fields, regulated by potentiometers of the 'fit and forget' type.



7 *Coating colour screens by dropping phosphor powder in stagnant air through the slits of the shadow-mask*

Summary

A television cathode-ray tube, whose thickness is only about a quarter of its screen diagonal, has been described. In this tube the electron beam is launched vertically downwards, is folded over on itself and runs for most of its length parallel to the picture screen. The principle of self-scanning and the application of the tube to colour television have been discussed.

The development work had to be carried out in a semi-empirical fashion, and although the possible mechanical errors which might occur in manufacture can be, to some extent, compensated by trimming devices, the tube is now at the stage where it should leave the university laboratory where it was created and undergo industrial developmental and production tests.

Radio-Interference Regulations

REGULATIONS designed to reduce electrical interference with wireless telegraphy, including domestic radio and television receivers, are being prepared following acceptance by the Postmaster General of recommendations by the Committee set up to advise him. This Committee, on Interference from Industrial, Scientific and Medical Radio-Frequency Apparatus, which was appointed in November 1956, has presented its first report. (The constitution of the Committee was given in the *Journal* for February 1957, p. 126.)

The Committee recommend that there should be regulations covering the manufacture and use of new electro-medical equipment and on the use of existing apparatus of this type, and that those regulations dealing with new equipment should come into force one year after being laid before Parliament and those dealing with existing equipment in three years.

A Review of the Proceedings, Parts A and B

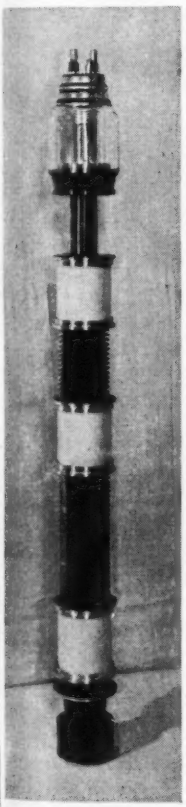
SHORT REVIEWS OF PAPERS

ON the following pages are some brief review articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

Ultra-High-Frequency Power Amplifiers

A short review of a Radio and Telecommunication Section paper (2734) with the above title, by J. Dain, M.A., Associate Member. The paper is published this month in Part B of the Proceedings. The author is with the English Electric Valve Co. Ltd.

THE PERFORMANCE OF POWER AMPLIFIERS IN THE 300–3000 Mc/s band has been improved greatly during the last 20 years. This has come about with the introduction of the klystron and the travelling-wave tube and also with advances in valve technology involving new materials and new methods of assembly.



1 *The K347: a 600 Mc/s klystron amplifier with a peak output of 500 kW*

Triodes and tetrodes have the advantages of small size and high efficiency compared with other classes of amplifier, and they can function satisfactorily as power valves at frequencies up to about 1 Gc/s. They are not at present recommended for higher frequencies because the short transit times necessary for efficient energy exchange between the electron current and the r.f. fields can be achieved only with cathode current densities in excess of 2 A/cm^2 and with electrode spacings of the order of 0·02 in. or less.

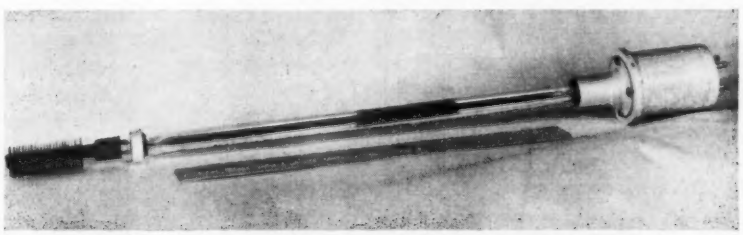
The most satisfactory construction has circular symmetry with disc seals or the equivalent and incorporates a low-loss material such as high-alumina-content ceramic for the insulators.

Modern multi-cavity klystrons are capable of average power outputs of 10 kW or more at any frequency within the band. In pulsed operation the peak power may be as high as several megawatts, but this is attainable only with beam voltages greater than 100 kV. The electron beam is usually focused by an axial magnetic field, but space-charge focusing is employed sometimes for simplicity if lower general performance is acceptable. Fig. 1 shows a 3-cavity amplifier for pulsed service at 600 Mc/s.

Klystron resonators are constructed either integral with the vacuum envelope or partially external to it. The second of these forms makes for greater versatility in any particular valve design but involves the use of low-loss ceramic insulators in the vacuum seals between the internal and external sections of the resonators.

Although klystron amplifiers can be built with stable power gains higher than 70 dB, their bandwidth is not markedly different from that of a triode or tetrode. It is for this reason that the travelling-wave tube has attracted attention. If a helix is used as the slow-wave r.f. circuit, this type of amplifier may have a 3 dB bandwidth of as much as one octave in frequency. The helix circuit, however, is not suited to high-power operation, and numerous structures have been devised to withstand greater heat dissipation. None has the outstanding wide-band feature of the helix, but some have been used in tubes capable of pulsed outputs up to about 1 MW at 3 Gc/s with bandwidths of roughly 10%. Fig. 2 shows a 15-watt travelling-wave tube for the band 1·7–2·3 Gc/s.

Backward-wave operation is one of the latest proposals for high-frequency amplifiers. This principle is based on



2 *The N1001: a 15-watt travelling-wave tube for the band 1·7–2·3 Gc/s*

electron interaction with an electromagnetic wave wherein the energy velocity is opposed to the phase velocity. These amplifiers are highly selective, but their centre frequency may be varied over a considerable range by adjusting some appropriate voltage applied to them. Crossed-field amplifiers have shown great promise and are of special interest by virtue of their intrinsically high efficiency.

While u.h.f. amplifiers now can meet the demands of many applications, significant improvements in performance are to be expected, particularly in the sphere of wide-band operation. 621.375.2.029.64

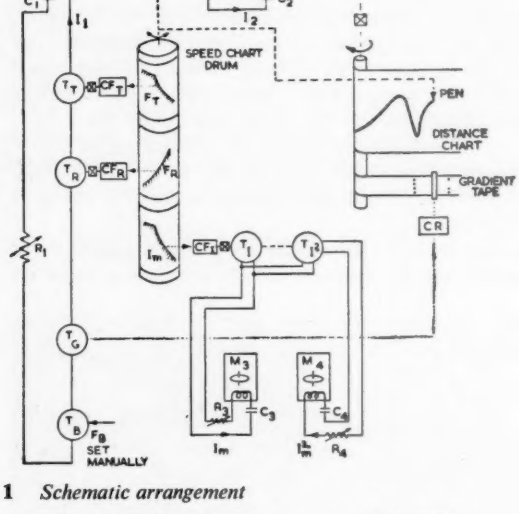
Train-Performance Computer

A short review of a Measurement and Control Section paper (2425) with the above title, by Prof. E. Bradshaw, M.B.E., Ph.D., M.Sc.Tech., Member, M. Wagstaff, M.Sc.Tech., Graduate, and F. Cooke. The paper was published individually in November 1957 and is republished this month in Part B of the Proceedings. Prof. Bradshaw and Mr. Cooke are at the Manchester College of Science and Technology. Mr. Wagstaff is with Ferranti Ltd.

IT IS ESSENTIAL THAT RAILWAY OPERATORS AND TRACTION-equipment designers should be able rapidly to evaluate the performance of a given train on a given route. Among the quantities which are of interest are accelerations, speeds, and times throughout the run, energy consumption and, if an electric drive is employed, the energy losses in the motors.

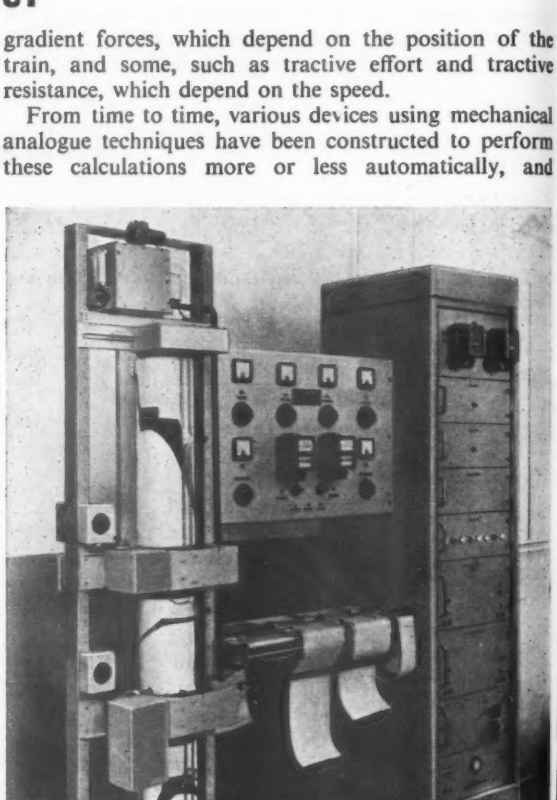
The traditional step-by-step methods of calculating train performance are tedious, even when use is made of approximate and 'short-cut' methods. Basically, they involve the calculation of the motion of the train from a knowledge of its effective mass and of the various working forces. These forces include some, such as gradient forces, which depend on the position of the train, and some, such as tractive effort and tractive resistance, which depend on the speed.

From time to time, various devices using mechanical analogue techniques have been constructed to perform these calculations more or less automatically, and recently the programming of a digital computer for this purpose has been described.



1 *Schematic arrangement*

> > > Photo-electric links
- - - - Mechanical links
. . . . Electrical control links
⊠ Gear-box



2 *A computer in use*

The present device is an electrical analogue computer in which induction energy meters are used as integrating elements. It is shown diagrammatically in Fig. 1, while Fig. 2 shows the actual appearance. The tractive effort, tractive resistance, gradient force and braking force are represented by the alternating voltages from variable

auto-transformers T_T, T_R, T_G and T_B, respectively. When connected in series, these auto-transformers produce a current in integrator M_1, and therefore a rate of rotation of the disc of this integrator proportional to the train acceleration. The angular displacement of this disc, which is proportional to speed, controls a variable auto-transformer T_V supplying current to the integrator M_2. The disc of M_2 has an angular displacement proportional to distance; its rotation controls a 'distance' chart, on which velocity is automatically plotted, and a gradient tape, on which the magnitudes and signs of the gradients are recorded in the form of coded punched holes. These coded gradient forces are continuously read to control T_G. The auto-transformers T_T and T_R are likewise controlled by curve followers which continuously read the values of tractive effort and tractive resistance from graphs of these quantities located on a drum, the angular rotation of which, controlled from M_1, is proportional to speed. The integrator M_1 also controls a pen which traces a speed record on the distance chart or on a time-operated chart (not shown in Fig. 1, but visible in Fig. 2).

The computer is therefore fully automatic. Manual control is needed only when the speed tends to exceed values defined by certain speed restrictions, which are conveniently pre-marked on the distance or gradient charts, or when it is desired to brake the train. For this latter operation, T_T, T_R and T_G are switched out and T_B set to represent the desired retardation rate.

In addition to the prediction of train motion, a curve reader, operating on a motor-current/speed curve, enables the quantity $\int Idt$, proportional to energy consumption per motor, to be determined by means of integrator M_3, and the quantity $\int I^2 dt$, proportional to motor losses, to be determined by integrator M_4.

It is a feature of the computer that most quantities are available both as an electrical equivalent (current or voltage) and a mechanical displacement (shaft rotation etc.). The computer is also particularly flexible regarding the number of points at which different ranges and scales may be introduced for operational convenience, by means of gear ratios and changes in the electrical circuit. A choice of scaling factors which results in the computation proceeding at or about real time has been found to be generally acceptable.

The saving of time which may be effected by such a computer varies with the problem being studied. It is greatest for long runs or for a series of runs under varying conditions which require little or no change in the prepared information supplied to the computer. Operators who have had experience of normal methods of calculation suggest that many problems can be solved about ten times more rapidly by means of the computer.

621.317.79 : 681.142

Simulation in Process Control

A short review of a Measurement and Control Section paper (2376) entitled 'The Simulation of Distributed-Parameter Systems, with Particular Reference to Process-Control Problems', by J. F. Meredith, B.Sc., Ph.D., Graduate, and E. A. Freeman, B.Sc., Graduate. The paper was published individually in July 1957 and is republished this month in Part B of the Proceedings. The authors are at King's College, Newcastle upon Tyne.

THE RAPID INCREASE IN THE APPLICATION OF AUTOMATIC feedback control to industrial processes in recent years has led to the need for methods of determining the transient performance of the plant to be controlled. It is often found (with, for example, heat exchangers, chemical processing plant and nuclear reactors) that the quantities to be controlled depend not only on time but also on a second independent variable, such as position. The transient analysis of such systems presents very considerable difficulty, and in consequence the control engineer very often resorts to the use of an analogue computer.

In their paper the authors review existing methods of simulation and develop a new technique suitable for non-linear distributed-parameter systems. The method of simulation is explained by considering a conveyor belt of length l, moving with a velocity v. A quantity of substance Q is placed on the belt at one end and removed at a point distant x from the origin at a rate R, which is dependent on both position and time. With this arrangement the quantity Q becomes a function of two independent variables—position x and time t. In order to solve an equation in two independent variables by using a simulator in which there is only one independent variable, namely time, the authors consider an element of the belt for which $x = \int_0^t v dt$ and thus eliminate x from the equation defining Q. Solving the resulting equation in the simulator is then equivalent to determining the quantity of substance Q on a particular section of the belt as this section moves through the system. When the section of the belt being considered reaches the end of the system (i.e. $x = l = \int_0^\tau v dt$, where $\tau =$ the time taken for the element to travel the length of the belt), the quantity of substance Q on the belt is selected and the simulator reset so that attention may be transferred to another element of the belt then at $x = 0$. By operating the simulator repetitively in this way, the quantity of substance Q at the end of the conveyor belt appears as a series of pulses separated by the time taken for an element of the belt to travel the length of the system. Thus, after peak rectification and smoothing of these bits of information, the quantity $Q(x = l, t)$ is determined.

The authors discuss the application of the simulation technique to two practical systems. In the first, a 'one-

side-mixed' heat exchanger, it is seen that variation in velocity of flow of the inner fluid may be introduced without difficulty. With the lumped-constant element analogue, as used by Ford, consideration of variable velocity leads to complication. For the second example, a non-linear distributed-parameter system, the authors show that the new technique reduces the amount of apparatus required by Ford's method by a factor of ten, and thus an inherently more reliable computer is obtained.

621.317.79 : 681.142 : 621.3.012.8

Magnetic Drum for Analogues

A short review of a Measurement and Control Section paper (2393) entitled 'A Magnetic-Drum Store for Analogue Computing', by J. L. Douce, M.Sc., Ph.D., Graduate, and J. C. West, Ph.D., D.Sc., Associate Member. The paper was published individually in July 1957 and is republished this month in Part B of the Proceedings. The authors are in the University of Manchester.

THIS PAPER CONSIDERS THE APPLICATION OF A RAPIDLY rotating magnetic-drum storage system for the recording and processing of analogue information. This form of storage is widely used in digital computing to give a high-capacity permanent store. Its chief disadvantage for digital-computing purposes is the relatively long time required to deliver the stored information. However, this feature is not so important in analogue computers, which often operate on a vastly slower time scale. Where the access time of the store is very small compared with significant time intervals in the analogue computer, the device may be regarded as a high-speed store, delivering and recording information as required during computation. A small analogue computer has been constructed to investigate the advantages of this particular form of storage system.

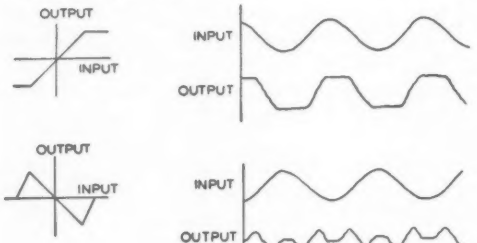
The basic equipment consists of a nickel-coated magnetic drum with combined 'read-write' heads situated near to the drum surface. Each head is made as narrow as possible so that many heads can be used with one drum. That portion of the drum surface associated with one head is termed a *track*. This nomenclature was adopted after observing the effect of accidentally bringing the head into contact with the rotating drum.

To eliminate the effects of drum eccentricity and non-uniform magnetic coating, analogue information is recorded by pulse-width modulation of a high-frequency (10 kc/s) carrier signal. This carrier frequency is obtained from a *clock* track on the drum.

As the magnetized drum surface passes by a head, the voltage induced into the 'read' winding is proportional to the rate of change of flux, and thus consists of alternate positive and negative pulses. These pulses are used to trigger a bi-stable multivibrator, reconstructing the original data as a train of pulses of variable mark/space ratio.

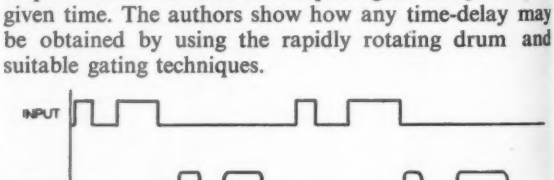
By gating the output of the play-back amplifier at a time interval exactly equal to the period of drum rotation, the particular voltage stored at any one point along a track can be obtained. Thus, if the time of application of the gating pulses is varied, preferably by means of an input voltage, the voltage recorded along different portions of a track is obtained at the output of the 'read' amplifier.

This provides an unusual form of non-linear-function generator in which the function is recorded along one track of the drum, and the input voltage to the non-linearity merely gates the play-back signal to give the correct output (Fig. 1).



1 *Response of non-linear-function generator*
a Non-linear function b Sinusoidal response

Since the drum provides a permanent store for recorded information, it is possible to record an input signal continuously and to gate the output of the 'read' amplifier so as to obtain the input signal delayed by a given time. The authors show how any time-delay may be obtained by using the rapidly rotating drum and suitable gating techniques.



2 *Response of delay network*

Fig. 2 shows the response of the synthesized delay unit to input steps and discontinuous sine waves.

621.317.79 : 681.142 : 621.395.625.3

SYNOPSES OF PAPERS

THE following are synopses of papers published in the *Proceedings* which have not been read at an Institution meeting and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints will be available shortly.

Circuit for Impedance Measurement from A.F. to V.H.F.

A synopsis of a Radio and Telecommunication Section paper (2709) entitled 'A Novel, High-Accuracy Circuit for the Measurement of Impedance in the A.F., R.F. and V.H.F. Ranges', by D. Karo, Dr.Eng., Ph.D., Dipl.Eng., Associate Member. The paper is published this month in Part B of the Proceedings. The author is in the Electrical Engineering Department, Birmingham College of Technology.

THE PAPER DESCRIBES A HIGH-ACCURACY MEASURING circuit suitable for frequencies from 50 c/s to v.h.f.

There are two branches in the circuit (one containing the unknown impedance), which are fed in phase opposition from the secondaries of two mutual inductors or two transformers.

Because of the opposition, the transfer impedances are very simple; no negative real terms are present, and no more than two variable standards are required for balance. In the majority of cases the angular frequency need not be known very accurately, and the calculations are simple.

Furthermore, at balance, the detector, source and all the circuit components except one have one terminal connected to earth. The potentials are therefore fixed, and most of the capacitances to earth are eliminated; those that remain shunt one secondary and the standard in one branch of the circuit and can easily be determined or otherwise taken into account in the calculations.

Tests have been made over a wide range of resistance, inductance and capacitance between 100 c/s and 50 Mc/s. The error varied, according to the standards and the frequency used, between $\pm 0{\cdot}001\%$ and $\pm 0{\cdot}01\%$.

621.317.33

Simple 3 cm Q-Meter

A synopsis of a Radio and Telecommunication Section paper (2745) with the above title, by A. E. Barrington, Ph.D., B.Sc.(Eng.), Associate Member, and J. R. Rees, Ph.D. The paper is published this month in Part B of the Proceedings. The authors are in Harvard University.

FOLLOWING A BRIEF REVIEW OF EXISTING REFLECTOMETER methods for the measurement of Q-factors of microwave cavities, a simplified system is described in which the complexity and cost of components are reduced appreciably. Values of Q-factors, from 200 to 4000, measured in this way agree well with those obtained with established techniques. Because the local oscillator is tuned manually, a frequency range wider than that obtainable with electronic tuning may be covered. 621.317.737

Radiation Patterns of Dipole Arrays

A synopsis of a Radio and Telecommunication Section paper (2740) entitled 'Methods of Calculating the Horizontal Radiation Patterns of Dipole Arrays Around a Support Mast', by P. Knight, B.A., Associate Member. The paper is published this month in Part B of the Proceedings. The author is with the British Broadcasting Corporation.

MANY V.H.F. BROADCAST TRANSMITTING AERIALS CONSIST of an array of dipoles mounted on a supporting mast. Some theoretical methods which may be used to determine their horizontal radiation patterns are described and their limitations discussed. Patterns calculated by these methods are compared with those measured using small-scale models. 621.396.674.3

Noise in Ionospheric-Scatter Signals

A synopsis of a Radio and Telecommunication Section paper (2743) entitled 'Simultaneous Variation of Amplitude and Phase of Gaussian Noise with Applications to Ionospheric Forward-Scatter Signals', by T. Hagfors, Siv. Ing., and B. Landmark, Dr.Phil. The paper is published this month in Part B of the Proceedings. The authors are at the Norwegian Defence Research Establishment.

THE CONDITIONAL PROBABILITY DENSITY $p(\phi|A)$ IS OBTAINED for Gaussian noise, where $\phi = \Psi_2 - \Psi_1$ is the difference in phase as observed at the two times t and $t + \tau$ and A the envelope at either t or $t + \tau$. The mean of $|\phi|$ subject to the condition of a particular value of A is evaluated using numerical methods, and the variation of $\overline{|\phi|}_A$ with A is discussed. A simple relation is obtained for the limiting case when $\tau \to 0$.

The noise character of the signal in an ionospheric-scatter circuit has been tested. It is concluded that the simultaneous variations of signal amplitude and phase are in good agreement with those to be expected for Gaussian noise and also that the assumption of a randomly phased angular spectrum appears to be justified. 621.396.8

OBITUARY

RICHARD WALTER GREGORY

Richard Walter Gregory who died at Hexham on the 10th May 1958, was born at North Cadbury, Somerset, in 1882, the elder son of R. R. C. Gregory, a notable figure of Castle Cary life in the 'nineties. In 1894 he entered Sexey's School, Bruton, where he distinguished himself both scholastically and at games, becoming one of the most outstanding and popular pupils. Until his death he continued to take a great interest in his old school and was a regular attender at the old boys' cricket match and annual meeting. From Bruton he went to Finsbury Technical College, being awarded a diploma in electrical engineering in 1901.

W. B. Woodhouse, who had been a lecturer at Finsbury, had gone to Newcastle upon Tyne to supervise the construction of Neptune Bank, the first 3-phase power station in the country, and at his invitation Gregory joined him and thus began his life-long association with the north-east coast. He was shortly transferred to the staff of Charles Merz, who was the consulting engineer for the Newcastle upon Tyne Electric Supply Co., to take charge of the electrical drawing office.

He thus became one of Charles Merz's earliest assistants in the pioneer development of electric power supply which took place on the north-east coast during the first decade of the century. He subsequently became chief electrical engineer and, in 1930, a partner in the firm of Merz and McLellan. During this period he was concerned in many electrical projects in various parts of the country and oversea and was responsible for many original designs and ideas, such as closed-circuit ventilation of alternators and direct connection of lead-covered cables to transformers. H.V. switching arrangements always had a great fascination for him, and he was intimately concerned with the late H. W. Clothier in the early development of iron-clad switchgear and, later, in the design of the first metalclad switchgear for heavy power-station work at North Tees and Carville 'B'.

He had always a special flair for and interest in architecture and was responsible for the architectural features of generating stations designed by his firm in Buenos Aires, Melbourne and elsewhere. At the end of 1933 he resigned his partnership in Merz and McLellan, after he had been incapacitated for a long period owing to a severe riding accident. However, he subsequently made a complete recovery and, in 1935, established in Newcastle his own consulting-engineering firm of R. W. Gregory and Partners, which became well known in the field of lighting, heating and ventilating.

Although so well known as one of our leading electrical engineers, he will also be remembered by a wider circle as one of the most delightful of companions with exceptional qualities of humour, friendliness, sympathy and tolerance which endeared him to all. These were coupled with a fund of anecdotes and reminiscences and considerable abilities as a writer and artist, one instance of which was the unusual Christmas cards which he designed year after year.

Apart from his professional activities he had many interests, such as meteorology, Rotary, farming and archaeology—he was quite an authority on the Roman Wall. He was a great lover of the countryside; and as a young man, usually with his lifelong friend and colleague the late William Hawthorne, he spent his week-ends walking on the hills and dales of the North and South Tyne and his holidays walking through relatively unknown country in Norway, Andorra, Corsica and Serbia. In 1957, after an interval of 50 years, he retraced his visit to Andorra—this time by bus.

In 1910 he married Margaret Henderson, of Newcastle, who survives him, as do his two married daughters and a son, who is a farmer in Northumberland.

Gregory joined The Institution as a Student in 1900 and was elected an Associate Member in 1909 and a Member in 1923. He served on the Newcastle Local Section Committee from 1914 to 1918 and was chairman in 1925. He was a member of the North-Eastern Centre Committee from 1927 to 1931 and from 1936 to 1940, becoming chairman in 1941. From 1940 to 1952 he was a member of the Wiring Regulations Committee. He served on the Council of the Association of Consulting Engineers and was a member of the North Eastern Electricity Consultative Council from its formation in 1949 until 1956. J. R. B.

ERNEST SIDNEY MORRIS

Ernest Sidney Morris, M.M., J.P., who died on the 6th May 1958 at his home in St. Helens, was born at Garston, Lancashire, on the 18th April 1896. He received his education at Garston School, Cowley School and St. Helens Technical College and was apprenticed at the glass works of Pilkington Bros., St. Helens. In the 1914–18 War he served with the West Lancashire Signals, then with the 55th Division. He was drafted to France, promoted to Sergeant, and awarded the Military Medal.

After the war, in March 1919, he joined Nuttall and Co., St. Helens, and in 1922 entered the service of United Glass Bottle Manufacturers. He remained in the employ of that firm until his retirement on the 1st January 1957, progressing through various grades and offices until he was appointed chief electrical and mechanical engineer in 1933 and later works manager. He was president of the works sports club and A.A.A. representative. On his firm's business he visited the United States and travelled extensively in the United Kingdom.

Morris took an active part in the public life of his town. He held many offices: he was a Justice of the Peace and chairman of St. Helens Rugby League Football Club and of the Providence Hospital Management Committee, and he held provincial and other degrees in Freemasonry. Morris was a keen supporter of Rugby League football and other forms of athletics, as well as showing notable skill at billiards and snooker.

He was a member of the principal St. Helens Congregational Church, where he was a strong supporter of the Boys' Brigade and a great help on sports days. Sid Morris, as he was always called, was widely known and respected in the district. In his work he was distinguished by his very progressive nature and his ability to adjust himself to changing conditions in technical and business matters.

Twice happily married, he leaves a widow and two married daughters.

He joined The Institution as an Associate in 1937 and was elected an Associate Member in 1941 and a Member in 1945. His paper entitled 'The Application of Electricity to the Annealing of Glass Bottles' was published in the *Journal* in 1942. W. I. P.

ERNEST ARTHUR REYNOLDS

Ernest Arthur Reynolds, M.A., who died on the 17th June 1958, was born on the 7th September 1877. He was educated at King Edward's High School, Birmingham, and at Pembroke College, Cambridge, where he secured first-class honours in the mathematical tripos and in the mechanical sciences tripos.

He first spent five years at the engineering works of Willans and Robinson at Rugby. Of this time, two years were spent in the workshops and trading office and three years on the testing-house staff on trial load tests of combined steam turbines and h.v. generators. In 1905 he entered the electrical contracting industry in partnership with the late J. D. Bradwell in Birmingham. He continued as principal of the business of Reynolds and Bradwell Ltd. until he died.

He was not content merely to work for himself. He became a member of the Electrical Contractors Association in 1911 and held many of its offices. He was twice elected vice-president and served on the E.C.A. Council from 1924 until his death. He served on many of the major committees in the electrical industry, and his counsel was always welcomed. He was especially interested in the training of youth and had served on the Advisory Committee of the City and Guilds of London Institute since 1928. He was chairman of the Committee for 28 years. He also served on many committees of the British Standards Institution and of the Electrical Research Association.

He was a man who combined a quiet charm with considerable

energy. Earlier n his career, he played Rugby football, and rowed for his college, and he played tennis with no mean ability until late in life. More recently, his great joy was his garden.

He will be sadly missed by a very wide circle of friends throughout the electrical industry, and especially by his widow, his two sons and his daughter.

He joined The Institution as an Associate in 1901 and was elected a Member in 1912. He served on the South Midland Centre Committee from 1922 to 1924, from 1934 to 1936, and from 1943 to 1946, being chairman in 1936–37. He served on the Council of The Institution from 1942 to 1945 and was a member of the Wiring Regulations Committee from 1930 until his death. L. C. P.

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings; as soon as these separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings, become available, price 2s., within two months of their appearance in the Proceedings.

Applications, quoting the serial number of the paper, monograph or reprint, as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually—if they do not take the Part of the Proceedings in which it will be republished—are urged to apply in due course for a reprint, as this is the final and correct version and includes the discussion.

PAPERS

Power-System Automatic Frequency-Control Techniques

Paper 2781 M: *Part A*

F. MORAN, M.SC.

THE author describes an instrument developed to record the phase variations between two 50c/s signals with a scale of $\pm 12\frac{1}{2}°$. The instrument was used during generator-stability tests to record phase variations between the reference busbar voltage and a voltage at a remote point in the system undisturbed by the tests. The measurements were required to correct the test-generator rotor-angle measurements.

To be read on the 2nd December 1958

The Deltic Locomotive *Paper* 2769 U: *Part A*

C. M. COCK

AFTER discussing the reasons for the production of low weight/power ratio locomotives and the influence of high-speed light-weight Diesel engines on this ratio, the author describes a 3300h.p. Diesel-electric locomotive and records the experience gained in its first 200000 miles of service.

To be read on the 11th December 1958

The Quarter-Wave Matching of Dispersive Materials

Paper 2736 R: *Part B*

J. S. SEELEY, B.SC.(ENG.), PH.D.

REFLECTIONS from the surfaces of dispersive materials used in broad-band aerial systems are highly frequency-dependent. A technique for matching such materials is described, and results are included of a successful application to the input surface of a dispersive prism.

To be read on the 24th November 1958

Investigations of Power-Follow-Current Phenomena using a Synthetic Power Source *Paper* 2707 S: *Part A*

L. L. ALSTON, B.SC.(ENG.), PH.D., *and* F. M. BRUCE, M.SC., PH.D.

CRITERIA for the development of a follow-current arc in a rod gap sparked over by the application of a high-voltage impulse were investigated, using a synthetic power source. The latter comprised a tuned *LC* circuit and could be adjusted to give a range of values for voltage, current, impedance and frequency. The effects of these variables, and of the impulse waveform, on the development of follow-current arcs in rod gaps up to 10cm spacing are discussed.

To be read on the 26th November 1958

Theory of Reflections from the Rodded-Type Artificial Dielectric

Paper 2742 R: *Part B*

A. CARNE, B.A., M.SC., *and* J. BROWN, M.A., PH.D.

IT is demonstrated that a composite material of a solid dielectric with embedded conductors can give a wave impedance equivalent to that of free space and thus eliminate interface reflections. A particular material, the rodded dielectric, is analysed, and design procedures are given which are exemplified by numerical results. An experimental verification of the design theory when the electric-field vector is wholly parallel to the axes of the rods is described, and the results show good agreement with theory. Methods of manufacture, and the tolerances required, are discussed.

To be read on the 24th November 1958

The Design and Performance of the Gas-Filled Cable System

Paper 2754 S: *Part A*

E. P. G. THORNTON *and* D. H. BOOTH, B.SC.(ENG.)

THE Gas-Filled cable system has been in commercial operation for 20 years, and since it was first described before The Institution in 1943 it has been modified in many points of detail as a result of very considerable service experience and intensive laboratory investigations.

After a brief note on the construction of the cable, a detailed description is given of the unique pre-impregnation process and of experimental work on the effects of the dielectric, quality of impregnation, material and constructional variables. An account is given of the design of accessories, the testing of cables and miniature systems, and present-day installation methods.

Operational experience with the system is discussed, and modifications resulting from service incidents are described. Possible future trends of development, leading to further technical and economic improvement, are considered.

To be read on the 17th December 1958

Papers and Monographs (*continued*)

High-Current-Density Thermionic Emitters—A Survey *Paper* 2750 R: *Part B*

A. H. W. BECK, B.SC.(ENG.)

THE steps leading to the development of modern emitters are described, and the characteristics and operation of such emitters are discussed.

To be read on the 19th January 1959

Power/Frequency Characteristics of the British Grid System *Paper* 2790 S: *Part A*

M. DAVIES, M.SC., PH.D., F. MORAN, M.SC., A.INST.P., *and* J. I. BIRD

AN account is given of tripping tests on the power/frequency characteristics of the Grid system for various conditions of plant and load.

The results of the tripping tests are applied to the problem of predicting the change in power transfer which occurs on a line connecting two large systems, as a result of a disturbance in either system, from a knowledge of the difference between the frequencies of the two systems before the interconnection is established. Further series of tests were carried out to investigate whether the relationship between the changes in power transfer and the frequency differences would apply in continuous operation.

It is shown that this relationship would apply for short periods or when the effects of manual control of the system are eliminated. For longer periods, of sufficient duration for the effects of manual control to be evident, it is necessary to use a reduced value for the power/frequency characteristic for the system having manual control.

To be read on the 2nd December

Subscriber Trunk Dialling *Paper* 2795 R: *Part B*

D. A. BARRON, M.SC.

PLANS have been prepared by the British Post Office to enable subscribers to dial their own trunk calls.

The service will be opened at Bristol Central Exchange in December 1958 and extended as rapidly as resources permit. By the end of 1961, subscriber trunk dialling (s.t.d.) is expected to be available in over 100 centres.

A national numbering scheme has been prepared, and ultimately a long-distance call from any part of the United Kingdom will be obtained by dialling the national number of the required subscriber. Local numbers will be unaffected.

Exchanges have been divided into groups for charging and routing purposes. The charging and routing will be controlled by register-translator equipment (Grace), an electronic form of which will be used for the larger installations.

In s.t.d. areas, new methods of charging for calls will be introduced. All calls will be timed, and the unit fee will be reduced to 2d. The existing 3-minute minimum charge will not apply to s.t.d. calls. Instead, unit fees will be recorded, each unit paying for a period of time which depends on the distance of the call. Both trunk and local units will be registered on existing subscribers' meters, and a bulked bill will be rendered. Private meters will be rented to subscribers who require them. Accounts will be sent to s.t.d. subscribers quarterly, and the preparation of accounts will be increasingly mechanized. A new coin-box has been developed so that trunk calls in s.t.d. areas can also be dialled by coin-box users.

To be read on the 22nd January 1959

The Use of Dispersive Artificial Dielectrics in a Beam-Scanning Prism *Paper* 2735 R: *Part B*

J. S. SEELEY, B.SC.(ENG.), PH.D., *and* J. BROWN, M.A., PH.D.

THE direction of a radiated beam can be altered by passing it through a prism. If the prism material is dispersive, the final direction is frequency-sensitive, and beam scanning can therefore be achieved by frequency modulation. Two types of dispersive artificial dielectric are considered for use in such a prism, one consisting of an array of rods and the other of an array of sheets containing a pattern of resonant slots. Measured values of the electrical constants of both arrays over a wide range of wavelengths are included, and the properties of the beam-scanning prism are described in detail.

To be read on the 24th November 1958

The Impulse Initiation of Arc Discharges *Paper* 2708 S: *Part A*

L. L. ALSTON, B.SC.(ENG.), PH.D.

AN analysis is made of discharge characteristics when arc initiation is just possible, and effects due to electrode material, shape and surface condition are studied. After the energy associated with the initial high-voltage pulse has dissipated, the current is of the order of 0·1 amp. The discharge is then unstable, and frequent transitions may occur between glow and arc conditions. Agreement has been obtained with discharge characteristics obtained in steady-state conditions.

Criteria for arc initiation are derived in terms of the discharge characteristics.

These results are significant for an understanding of the development of a power arc in the path of a surge breakdown on electrical apparatus, especially for gaps up to about 1 cm.

To be read on the 26th November 1958

MONOGRAPH

The Conductivity of Oxide Cathodes. Part 6—Conductivity in a Magnetic Field *Monograph* 317 R

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.)

IN this Part the conductivity of the oxide-cathode matrix in an S-type valve in the presence of a magnetic field is examined, and it is shown that the matrix exhibits a powerful magnetic-resistance effect. However, the effect occurs only when the electron transfer is by free flight through the hollow pores of the matrix and when the magnetic field is in a transverse direction; the solid-particle phase of the conduction mechanism shows no measurable magneto-resistance effect.

District Meetings

ARRANGEMENTS for District Meetings in November and December other than those in the area of a Local Centre

November 1958

READING (At the George Hotel, King Street, at 7.15 p.m.)

24 *Monday* R. H. ABELL 'American Electricity-Supply Practice'

December 1958

MAIDSTONE (At the Medway College of Technology, Chatham, at 6.30 p.m. for 7.0 p.m.)

1 *Monday* F. H. LAST, PH.D.(ENG.), B.SC.(ENG.), E. MILLS, and N. D. NORRIS 'Organization for Large-Scale Grid-System Tests'

SOME RECENT BOOKS

H. H. BROUGHTON
ELECTRIC CRANES

SPON. 1958. 3RD EDITION. 511 PP. £7 10S.

THE rarity of standard textbooks on electric cranes ensures a welcome to the third edition of this manual. The late Mr. Broughton set himself an unenviable task in trying to compress a very large quantity of relevant matter into a volume of even 511 pages.

The subject-matter covers the mechanical, structural and electrical design of the four principal types of electric crane in a most comprehensive way and is liberally sprinkled with drawings, tables and illustrations. Design details of actual representative examples of cranes in each category are a valuable feature.

To the student and young designer, seeking basic information, this book is a veritable storehouse of sound engineering practice in crane design. As such, it is thoroughly recommended for study, but its price will keep it more in the library than on the private bookshelf. The qualified engineer, seeking practical up-to-date design information and an assessment of future trends, may find the volume less useful, although it certainly provides a valuable stepping stone to further knowledge through the comprehensive bibliography at the end of each chapter.

Much of the text is not new and is familiar to many engineers. In its place, more space could have been given to matters both mechanical and electrical which are but briefly mentioned. In the mechanical sections, these include welding of crane structures, stress analysis based on more recent research, and the use of light-alloy sections. In the electrical sections, more data about taper rotor motors, eddy-current coupling drives, and the application of electronic techniques to crane control would have been useful. A section devoted to erection and maintenance and their influence on crane design could well have been included. In chapter 23 the diagrams of connections reprinted from several makers' literature are a little confusing because not redrawn with standard symbols for components.

The fact that criticism of this manual is directed more to omission than commission should not detract from its value as a well compiled textbook of electric-crane practice, both at home and abroad.

W. EHRENBERG
ELECTRIC CONDUCTION IN SEMICONDUCTORS AND METALS

OXFORD. 1958. 389 PP. £3 3S.

THE first nine chapters of this book, occupying rather more than half of the whole volume, are concerned with the establishment of a formal mathematical theory of the conduction of electricity in metals and semiconductors. Formulae are derived not only for electrical conductivity, but also for thermo-electric and galvanomagnetic constants. The treatment is unusual in that four chapters are devoted to a detailed examination of the results that can be obtained on the assumption that the electrons in a conducting solid behave as particles, and it is not until p. 82 that wave-mechanical concepts are introduced and the energy-band structure described. This arrangement has the merit of allowing the author to emphasize the assumptions involved in various approximations that are commonly used, but it results in giving the treatment as a whole something of the flavour of an academic exercise.

The second half of the book is largely descriptive and is concerned with the application of the formal theory to practical cases. Perhaps the most interesting chapter in this part is one in which the linear electrical properties of semiconductors are reviewed, since it deals not only with elementary semiconductors such as silicon and germanium, but also with ionic compounds, valency-controlled semiconductors, intermetallic compounds, and organic semiconductors. This attempt to correlate the properties of such a wide range of materials is very welcome. The remaining chapters are concerned with the theory of rectifiers and transistors and with a number of related topics.

The book as a whole will appeal more to theoretical physicists than to engineers, since the reader is left with the impression that the author is interested in practical devices such as transistors only in so far as they furnish examples to which the formal mathematical treatment can be applied. Furthermore, although the author states in his preface that the 'book is written as an introduction to the physics of semiconductors', most people will probably prefer to approach this perplexing subject by way of one of the many books in which emphasis is placed on physical principles rather than on mathematical formulae. For those who already have some knowledge of the subject, Ehrenberg's treatise will form a useful reference book

J. L. STEWART
CIRCUIT ANALYSIS OF TRANSMISSION LINES

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 186 PP. £2 4S.

THIS book provides a unified treatment of transmission lines, their theory and application. The principal topics covered are: propagation of both transient and sinusoidal waves along uniform lines; efficiency and matching; lines as resonators; equivalent lumped circuits; measurements and standing-wave ratio; and transmission-line charts. The approach is analytical rather than graphical, with considerable emphasis on physical implication. This emphasis is exemplified by the order in which certain topics are treated. Thus a detailed physical picture of multiple reflections in a mismatched line excited by a simple step wave precedes and paves the way for the formal steady-state solution. Problems are given at the end of each chapter, and an appendix contains some useful but regrettably brief design data.

The general level of the book might be described as 'preparatory'. It would suit the graduate engineer embarking on specialized work in this field. However, it would not be long before he would be seeking stronger meat—or at least

so one would hope. Reference is given to some 30 textbooks, but little mention is made of original papers.

A weak feature of the book is its style. The language ranges from the obscure:

> Before proceeding with the theory of the technique (which is not simple in its derivation), it is worthwhile to reason out an existence possibility for the method which helps in pointing out why the method is valuable for measuring small discontinuities (p. 141)

to the chatty:

> The 'smart' designer makes the bypass capacitor series resonate with its own lead inductance . . . (p. 123).

A second source of irritation is the excessive use of footnotes. In 180 pages of text there are approximately 140 footnotes. Of these the following wins the prize for sheer irrelevance:

> On a purely economic basis, atomic energy cannot compete with conventional fuels in the United States . . . until natural resources of gas, coal, and oil are severely depleted (which may not be as far away as most people think) (p. 124).

It is a pity that the book is marred by the jargon and the digressions, for the style is otherwise lucid and explanatory, with particular care paid to stumbling blocks such as the difference between phase and group velocities.

A. T. DOVER

POWER WIRING DIAGRAMS

PITMAN. 4TH EDITION. 1958. 191 PP. 16s.

THE present work forms the fourth edition of this handbook and is its first revision since the war. It has been brought completely up to date on very comprehensive lines and includes no fewer than 229 diagrams, most of which are diagrams of connections. It also includes several tables of useful data: among the items dealt with may be cited the approximate full-load currents of motors, the sizes and ratings of fuse wires, and the current ratings of cables.

The field covered is wide. Starting with the simple d.c. motor and d.c. machines generally, arc-welding generators and rectifiers (mercury-arc) are included. A.C. motors and transformers are dealt with, followed by instruments, relays and switchgear, while, among the more specialized applications, protective systems and automatic voltage regulators are shown.

The book will be of value, not only to draughtsmen engaged in laying out schemes, but also to the vast majority of installation and maintenance engineers, whether their object be the understanding of existing gear or the consideration of extensions of plant.

The Provision of Adequate Electrical Installations in Buildings

ON the 27th November, a Symposium on 'The Provision of Adequate Electrical Installations in Buildings', arranged by the Utilization Section, will take place in the Institution building from 2.30 p.m. until the evening. The programme is expected to interest not only members of The Institution but also architects, builders, contractors and others. The four papers being read will be preceded by an introduction by Mr. R. A. Marryat, Chairman of the Utilization Section, and followed by a discussion.

Copies of the introduction and the four papers can be obtained in advance of the meeting on application to the Secretary. Synopses of the four papers are given below.

Multi-Storey Flats and Maisonettes

C. A. BELCHER

THE paper deals chiefly with buildings subsidized by local authorities, where the spending of public money must be restricted to essentials. It begins with a sociological study of tenants' views on socket-outlets and continues with a discussion of choice of materials and general design, including main cable runs and consumers' control units, for electrical installations in such buildings. Wiring systems and the use of single-core protective multiple-earthed neutral circuits are considered. Other aspects covered include floor-warming, lift services, public-lighting requirements, boiler-house electrical equipment, and the reception of radio and television.

Houses

C. C. HYAMS

IN considering the general design of electrical installations in medium-priced houses, the author stresses the desirability of estimating both immediate and anticipated requirements at the initial planning stage. The positioning of socket-outlets is of great importance, and suggestions are made for various rooms. In the selection of lighting appliances and other electrical accessories, the factor of pleasing appearance arises, and the use of good-quality products is advised. The modernization of existing installations, electricity in the garden, and safety and testing are also discussed.

Commercial Buildings

E. E. JACOBI

THE provision of adequate wiring in office buildings involves the assessment of a growth factor and a diversity factor. Differentiation has to be made, in calculating the immediate known load, between services which affect the load and those which do not. The paper covers present-day requirements of lighting, heating and cooking equipment. Reference is also made to tariffs. Main distribution and control units, wiring methods and ducts are discussed, and installation costs are estimated. Brief reference is made to hotels and shops.

Small Industrial Premises

J. A. SHARP

A CONNECTED load of up to 200kVA is used to define 'small industrial premises' in this paper. To cater for load development, at least 25% spare capacity should be allowed on main control gear, distribution boards and sub-mains, since factories normally expand, however small they may be initially. The need for closer liaison between architect, consultant and contractor is stressed. Wiring systems, control and distribution, space heating, lighting, and power-factor correction are extensively treated. Safety regulations and codes of practice are listed.

The Incorporated Benevolent Fund: Annual Report

THE Report of the Court of Governors of the Incorporated Benevolent Fund was presented at the Annual General Meeting of the members of the Fund on the 22nd October 1958. The Report, together with the Accounts, was circulated with the September *Journal*.

The total capital of the Fund stood at £149224 on the 30th June 1958. Subscriptions and donations during the year showed an increase from £13765 (in 1957) to £15475. This welcome increase is largely attributable to the Appeal circulated by the President with the December 1957 issue of the *Journal*, which with other efforts, in addition to producing increased annual subscriptions, resulted in 350 new Deeds of Covenant, raising the Fund's annual income (with refund of income tax) by approximately £700.

Compared with last year, however, the expenditure has also risen, and this is partly due to the distributed grants having increased by nearly £800. The cost of grants plus management and maintenance charges was £14707, and although this was a little less than the sum received from subscriptions and donations, every effort must be made to continue to increase the income annually, as only by this means can the Court of Governors increase the assistance given to beneficiaries. Grants to 132 beneficiaries with 112 dependants amounted to £10506—an average amount of £80 per beneficiary. Seven legacies were received, amounting to approximately £900, and also royalties on a book.

The number of new cases (29) has increased considerably during the past 12 months, but this has been offset by the discontinuance of grants in 13 cases, by reason either of death or of improvement in circumstances. Some of these latter beneficiaries had been in receipt of assistance for 25 years.

The Fund now has five beneficiaries resident in the Crossways Trust homes at West Worthing, Brighton, and Englefield Green, and this collaboration has provided help for elderly people who are no longer able to cater for their own needs.

Refund of income tax. A sum of £2043 was recovered from the Income Tax Commissioners, owing to the kindness of members who subscribed by covenant. A further £4500 could be saved if all subscribers of over 10s. per annum would use the covenant to subscribe for seven years, a procedure which involves no other obligation.

Homes Fund. The total amount received in subscriptions and donations from the inception of the Fund to the 30th June 1958 was £40493. The cost of erection of houses and flats on 'The Chesters' estate, construction of the road and laying out of the grounds amounted to about £59500. All the houses on the estate are occupied, and the pleasure taken in their homes by the residents is most rewarding to the Court. Members of the Fund can take justifiable pride in the wonderful results achieved by this scheme.

Wilde Fund. The accounts of the Wilde Fund were published in the July 1958 *Journal*, p. 380.

Lord Hirst Fund. On the 30th June 1958 the Fund comprised:

Capital Account investments	£11543 3s. 10d.
Income Account investments	£3989 11s. 2d.

which produce an annual income of about £627. The uninvested balance of the Income Account was £8 0s. 4d. Grants totalling £250 were made from this Fund during the year.

MEDICAL ELECTRONICS DISCUSSION GROUP

AT a very successful first gathering of the Medical Electronics Discussion Group on the 7th November 1958, there was a discussion on 'Problems in the measurement of blood flow'. The opening speaker was Dr. A. C. Dornhorst, M.D., F.R.C.P., Reader in Medicine, St. Thomas's Hospital Medical School, who dealt with 'Measurements in the human subject'; and he was followed by Dr. D. A. McDonald, D.M., D.SC., Reader in Physiology, Medical College of St. Bartholomew's Hospital, who spoke on 'Measurement of pulsatile blood flow'.

On the 7th October 1958 an Organizing Committee, responsible for arranging the programme of the Group, had been appointed, with these members:

S. J. Emerson, M.ENG., MEMBER (Chairman)
J. A. V. Bates, M.A., M.B., B.CH.
C. K. Battye, B.SC., M.SC.
P. Bauwens, M.R.C.S., M.R.C.P.
F. T. Farmer, PH.D., B.SC.(ENG.), MEMBER
J. W. Gallop, B.SC.(ENG.), MEMBER
E. Garthwaite, M.B.E.
R. E. George
T. E. Ivall
W. C. Lister, B.SC., MEMBER
D. A. McDonald, M.A., D.M., D.SC.
J. W. McLaren, M.A., F.F.R., D.M.R.E.
R. C. G. Williams, PH.D., B.SC.(ENG.), MEMBER
A. Nemet, DR.SC.TECHN., MEMBER
A. Nightingale, M.A., PH.D.
Prof. W. C. W. Nixon, M.D., F.R.C.S., F.R.C.O.G.
G. Parr, MEMBER
W. J. Perkins, ASSOCIATE MEMBER
S. N. Pocock, ASSOCIATE MEMBER
B. Shackel, M.A.
J. C. Shaw, B.SC., ASSOCIATE MEMBER
S. L. Sherwood, L.R.C.P., L.R.C.S.
C. N. Smyth, M.A., B.SC.(ENG.), M.B., B.CH., MEMBER
G. F. Thick
A. S. Velate

They decided that the activities of the Group should be concerned with advanced electronic techniques applied or related to medical and biological problems.

A second discussion meeting will be held on Friday, 28th November, in the Institution building at 6.0 p.m. (tea at 5.30 p.m.), on the problems encountered in neurophysiology. Dr. Warren S. McCulloch, M.D., Massachusetts Institute of Technology, and Dr. W. K. Taylor, B.SC., M.SC., PH.D., ASSOCIATE MEMBER, Department of Anatomy, University College London, have agreed to speak at the meeting. It is planned to hold a third meeting in January 1959, to deal with 'The physiologists' requirements for d.c. amplifiers'.

In the course of each discussion meeting, members can give notice of problems they have encountered (not necessarily related to the topic discussed at the meeting), the others present being invited to offer suggestions for their resolution.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

KUNIN, R. 541.13

Ion Exchange Resins. 2nd ed.

London, Chapman and Hall, 1958. pp. xiii, 466. 24 × 15 cm. £4 8s.

This is an up-to-date survey of a technique in electrochemistry which is proving to have applications in many fields. Its use for water softening will particularly interest engineers.

LAVER, F. J. M. 621.3

Electric Power

London, Oxford University Press, 1958. pp. 80. 22 × 14 cm. 7s. 6d.

A descriptive introduction for the layman or schoolboy to the electrical and magnetic effects which are the basis of electric power.

LOEB, L. B. 621.319

Static Electrification*

Berlin, Springer, 1958. pp. xii, 240. 25 × 16 cm. £4 4s.

This book is based on many years of research and is a summary of the results so far obtained. It deals with electrolytic processes in static charging, contact charging, spray electrification, contact charging between solids, and effects of ionization of gases.

MEYLER, D. S., and SUTTON, O. G. 53 (083)

A Compendium of Mathematics and Physics

London, English Universities Press, 1958. pp. x, 384. 22 × 14 cm. 25s.

This compendium is for research workers wanting a book in which to look up a theorem or formula to find out in what conditions it holds and how to apply it, and for students who want a summary of what is known in various branches of mathematics and physics.

MICHAILOW, W. W. 621.315.027.3

Berechnung und Konstruktion von Hochspannungsapparaten (Design and construction of h.v. apparatus)

Berlin, VEB Verlag Technik, 1953. pp. 213. 24 × 17 cm. £1 18s. 0d.

A translation into German from the Russian. The first part deals with design considerations, including the behaviour of insulators and contacts; the second part is concerned with constructional details of equipment for h.v. power systems.

MORLEY, A., and HUGHES, E. 53

Elementary Engineering Science. 4th ed.

London, Longmans, Green, 1957. pp. xi, 381. 19 × 13 cm. 11s. 6d.

Covers the mechanics, heat and electricity sections of the syllabus in science, 'O' level, of the G.C.E. and the first-year syllabus in electrical-engineering principles of the City and Guilds courses for electrical technicians. The M.K.S. system has been adopted for this edition.

NURNBERG, W. 621.3.001.4

Die Prüfung elektrischer Maschinen einschliesslich der modernen Querfeld-maschinen (The testing of electric machines, including modern transverse machines). **3rd ed.**

Berlin, Springer, 1955. pp. ix, 414. 24 × 16 cm. £2 10s. 3d.

The methods and apparatus for measuring electrical quantities and performance are dealt with in a full and up-to-date manner. Testing is described, not only for transformers and simple rotating machines, but also for a.c. commutator machines and metadynes.

OLLENDORFF, F. 537.533.7

Elektronik des Einzelelektrons (Technische Elektrodynamik. Band II) [Electronics of the single electron (Technical Electrodynamics. Vol. 2)]

Vienna, Springer, 1955. pp. xii, 643. 25 × 17 cm. £18 7s.

This is an advanced treatment, dealing mainly with the physics of electron optics.

OTTO, C. A. (Editor) 621.365

Electric Furnaces*

London, Newnes, 1958. pp. vii, 248. 22 × 14 cm. 35s.

A survey of the various types of electric furnace which have been developed for melting, refining, annealing and other processes and their applications in various industries.

PIPES, L. A. 517

Applied Mathematics for Engineers and Physicists. 2nd ed.*

London, McGraw-Hill, 1958. pp. xi, 723. 23 × 16 cm. £3 8s.

Covers infinite series, complex numbers, Fourier analysis, the Laplace transform theory, vector and tensor analysis, partial differential equations, matrices, the calculus of variations, and non-linear differential equations. It contains problems to be worked, and references to further reading follow each chapter.

RICHMOND, A. E. 517

Calculus for Electronics*

London, McGraw-Hill, 1958. pp. viii, 407. 23 × 15 cm. £2 6s. 6d.

This book on the application of the calculus to problems in electronics contains some 450 practical problems to be worked. The M.K.S. system is used almost exclusively in the text.

ROBERTS, A. 628.972

Underground Lighting in Mines, Shafts and Tunnels*

London, Technical Press, 1958. pp. xii, 292. 26 × 17 cm. £3 3s.

This practical work is divided into three parts. It deals with the fundamentals of illumination, explains the special problems of underground lighting, particularly in coal mines and in explosive atmospheres, and describes equipment and actual installations. It will be reviewed in a future issue.

SCROGGIE, M. G. 621.396

Foundations of Wireless. 7th ed.*

London, Iliffe, 1958. pp. ix, 388. 22 × 14 cm. 15s.

While this well known work retains its original form, it has been thoroughly revised for this new edition and now, for instance, includes two chapters dealing with transistors.

SEELY, S. 621.385

Electron-Tube Circuits. 2nd ed.*

London, McGraw-Hill, 1958. pp. xi, 695. 23 × 15 cm. £4 1s. 6d.

This edition covers some aspects of the theory and applications of transistors.

SHEPHERD, A. A. 621.315.59

An Introduction to the Theory and Practice of Semiconductors*

London, Constable, 1958. pp. 206. 20 × 14 cm. 18s. 6d.

A book for advanced students and graduate workers in physics. It deals with conduction in semiconductors, the properties of single crystals, rectification, transistors and light-sensitive devices, and the preparation of germanium and silicon crystals. It will be reviewed in a future issue.

SIEMENS, W. VON 92 (SE1)

Lebenserinnerungen (Personal recollections)

Munich, Prestel, 1956. pp. 307. 24 × 19 cm

This is a reissue of a work which was translated into English and published in 1893. The new edition contains many interesting illustrations.

SIROTINSKI, L. I. (Editor) 621.315.027.3

Hochspannungstechnik. Band I (H.V. technique. Vol. 1)

Teil I—Gasentladungen (Part 1—Gas discharges). 1955. pp. 298. 34s.

Teil II—Hochspannungsmessungen. Hochspannungslaboratorien (Part 2—H.V. measurements; H.V. laboratories). 1956. pp. 259. £2

Berlin, VEB Verlag Technik. 24 × 17 cm

Part 1 deals with discharges in gases, including lightning and corona effects. Part 2 describes measuring techniques and laboratory testing arrangements.

SOLODOVNIKOV, V. V., TOPCHEEV, Yu I., and KRUTIKOVA, G. V. 621–52

Procedure for Obtaining Transient Response from Frequency Response with Tables and Nomographs*

London, Infosearch, 1958. pp. 193. 25 × 17 cm. £2 2s.

This is a translation from the Russian. It is concerned with the use of trapezoidal frequency responses for the derivation of transient responses used in the theory of automatic control. A particular feature of the book is the set of tables of h_k functions. The book was reviewed in the September Journal, p. 514.

STURLEY, K. R. 621.396.619

Frequency-Modulated Radio. An Introduction to the Theory, Design, Construction and Servicing of VHF/FM Receivers. **2nd ed.***

London, Newnes, 1958. pp. vii, 120. 19 × 13 cm. 15s.

Explains the general principles for the practical man.

VAJDA, S. 658

Readings in Linear Programming

London, Pitman, 1958. pp. vii, 99. 22 × 14 cm. 20s.

Deals with the mathematical methods used in operational research. Examples are given of practical applications.

WATTS, J. L. 621.313.004

Electrical Maintenance and Repairs*

London, Cleaver-Hume, 1958. pp. 324. 19 × 13 cm. 21s.

Covers routine inspection and maintenance, fault location and repairs on wiring installations, plant and plant-control gear.

WRIGHT, D. A. 621.315.59

Semi-Conductors. 3rd ed.*

London, Methuen, 1958. pp. 136. 17 × 11 cm. 8s. 6d.

This monograph is described as an elementary account of the properties of semiconductors. It deals especially with the theory of electron flow in them, and across the boundary between them and either a metal or a vacuum. The treatment of transistors has been further expanded in this edition, and the section on thermo-electricity has been amended.

ZWORYKIN, V. K., RAMBERG, E. G., and FLORY, L. E. 621.397.9

Television in Science and Industry*

London, Chapman and Hall, 1958. pp. xii, 300. 24 × 15 cm. £4

Discusses the fields of application of closed-circuit television, and the equipment which has been developed, especially for miniaturization and colour and stereo television. It will be reviewed in a future issue.

OTHER PUBLICATIONS

BRITISH RADIO VALVE MANUFACTURERS' ASSOCIATION

The Use of Semiconductor Devices

London, British Radio Valve Manufacturers' Association, 1958. pp. 36. 18·5 × 12 cm

ENGINEERS COUNCIL FOR PROFESSIONAL DEVELOPMENT

Eusec Engineering Education and Training. U.S.A. Contribution to Eusec Conference, Paris, France, September 16–20, 1957

New York, American Society of Mechanical Engineers, 1957. pp. 64. 27·5 × 22 cm. $5.00

INSTITUTION OF MECHANICAL ENGINEERS

British Contribution to the Third Eusec Conference on Engineering Education, Paris, September 1957

London, Institution of Mechanical Engineers, 1958. pp. 101. 28 × 22 cm. 20s.

Proceedings of the Third Eusec Conference on Engineering Education

London, Institution of Mechanical Engineers, 1958. pp. 106. 28 × 22 cm. 30s.

INSTITUTE OF PETROLEUM

Symposium on Insulating Oils, March 1958—Preprints

London, Institute of Petroleum, 1958. pp. 97. 28 × 22 cm. 10s.

INSTITUTE OF RADIO ENGINEERS, ELECTRONIC INDUSTRIES ASSOCIATION, AMERICAN SOCIETY FOR QUALITY CONTROL, AND AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Proceedings Fourth National Symposium on Reliability and Quality Control in Electronics, Washington, D.C. January 6–8, 1958

New York, I.R.E., 1958. pp. iv, 354. 28 × 21 cm. £2 4s.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

The Industrial Challenge of Nuclear Energy. Research—Uses—Social Problems. Papers Given During the Second Information Conference on Nuclear Energy for Management, Amsterdam, 24–28 June, 1957

Paris, O.E.E.C., 1958. pp. 301. 24 × 15 cm. 20s.

The Theory of Marginal Cost and Electricity Rates

Paris, O.E.E.C., 1958. pp. 79. 24 × 15 cm. 6s.

Reviewed in the September Journal, p. 516

The European Nuclear Energy Agency and the Eurochemic Company. 1st Report of the Steering Committee for Nuclear Energy to the O.E.E.C. Council

Paris, O.E.E.C., 1958. pp. 192. 24 × 16 cm. 12s.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 1st October 1958

ELECTIONS

Associate Members

ALLEN, Robert Huntington, D.F.C., B.SC.(ENG.)
BROWNLOW, William Harold
BULLEN, Stephen Wilfred
BURGESS, James
CIUCIURA, Aleksy, B.SC.(ENG.)
CULLEN, Charles Gavin
DASHWOOD, Jack Frederick
DEITON, Dudley Harry
FANSHAWE, Cmdr. Robert Henry, R.N.
FELTON, Maj. Frederick Albert, R.SIGNALS
FERRISS, Ronald Francis Edwin, B.E.
FITCH, Edgar, B.SC.
GOLDNER, Henry
GOODRICH, Frank Gordon, B.SC.
HART, Willoughby
HENTY, Gordon Alfred
HIME, Charles William
INIE, Victor
KELL, Robert, B.SC.(ENG.)
KIFT, Francis
LAWS, Robert Alan, B.SC.
MACMILLAN, Robert Hugh, M.A.
McNUFF, Frank
PORTER, Air Comm. Melvin Kenneth Drowley, C.B.E., R.A.F.
PSALIDAS, Michael
READMAN, Alan
REID, Herbert Arthur, B.SC.(ENG.)
ROBINSON, Ernest Henry
SIMCOX, Gordon Kenneth Howard, B.SC.(ENG.)
SMITH, Frederick Graham
SMITH, Leslie George
SMITH, Norman Henry Arthur, B.SC.
STEVENSON-JONES, Ralph, B.SC.(ENG.)
SZENTIRMAI, George
WALLACE, James
WATSON, Edward Bruce
WEATHERBY, Albert
WEST, William Percival David
WESTWATER, Instr.-Capt. Frank Lorimer, O.B.E., M.A., B.A., R.N.(RET.)
WOOLLEY, Henry Charles

Associates

BARBER, Derrick Edward
CHUNG, Lian Fatt
CLOTHER, Robert Leonard
GREAVES, Stanley
KEELING, Alfred Samuel
MAROOFIAN, Rahim
MORTIMER-HAWKINS, John
PARSONS, John Thurstan
SMITH, George Albert

TRANSFERS

Associate Member to Member

ALEXANDER, Eric William George
ALI, Syed Nazeer
ALLEN, Robert Girdlestone
BARLOW, Herbert Dudley
BEECROFT, John
CHICK, Percival Gaymer
DHARAP, Prabhakar Waman, B.A.
EVANS, Owen Thomas
FAIRBAIRN, Eric Playfair, B.SC.
FAWCETT, Dennis, B.SC.(ENG.)
FEINER, Arthur
FREELING, Francis Frederick
GHOSH, Prof. Chandra Sekhar, M.SC., S.M.
GRIERSON, Robert
HALBE, Dhundiraj Narayan, B.ENG., B.SC.(ENG.)
HALL, Edward Albert James, B.SC., PH.D.
HARRIS, Frederick Llewellyn
HENDERSON, John Stuart, B.SC.
HODGSON, Charles Hubert
JACOBSEN, Bent Bülow, B.SC.(ENG.)
KARO, David, DR.ENG., PH.D.
KINSMAN, Alverton Denbigh
LACKIE, Donald Walker
LITTLE, Stanley James
MACKENZIE, Lt.-Col. David Hugh Almroth, M.B.E., R.E.M.E.
MATHER, Brev.-Col. William Harvey, O.B.E., T.D.
MILLARD, Robert George
PEATHEY-JOHNS, Lt.-Col. Francis Royston, M.B.E., B.SC.(ENG.), R.E.M.E.
ROBERTS, Leslie Frank, B.SC.
SHIELDS, Col. Ronald Frederick, O.B.E., B.SC.(ENG.), R.E.M.E.
SIMPSON, George Linklater, B.SC.
SLINGSBY, Stanley
SMITHSON, George Frank Bailey
TARBATT, George Edric
THOMAS, Adin Bryn, M.A.
TRIER, Peter Eugene, M.A.
WARD, Maj. Albert John Clarke
WARREN, William Phillip, B.SC.
WELBOURN, Donald Burkewood, M.A.
WHALLEY, Geoffrey Forster
WHITEHEAD, James Rennie, B.SC., PH.D.

Associate to Associate Member

EFFEMEY, Harry George

Graduate to Associate Member

ADAMS, Robert John
AINSWORTH, John
ALCOCK, Bede John, B.SC., PH.D.
ANDERSON, George Russell
ANNIS, Eric Reginald John, B.SC.
ATKINS, Leslie William
AUSTIN, Stanley Joseph
BAILEY, Donald Frank
BAISTER, Colin, B.SC.
BALDREY, Herbert William
BALLINGER, Albert Leslie
BESSANT, Jack William
BHANDARI, Krishan Kumar, B.A., B.SC.
BINNS, Norman
BOUTALL, Henry William
BREINGAN, Frederick
BROWN, George Henry, B.SC.
BRUNT, Norman
BUNTING, Stanley Cushman
BURDEN, David Frederick
BUTSON, Denis John
BUTTERS, John William Wentworth, M.E.
CARR, James
CHAMBERS, Ronald Fulton, B.SC.
CHIVERS, Edgar Leslie
CHOPRA, Paul, B.SC., B.SC.(ENG.)
CHUSTECKI, Feliks Marian
CLARK, John Sydney
COLEMAN, Donald Raymond, B.SC.(ENG.)
CONNOR, Robert William Hamilton

Graduate to Associate Member (contd.)

COTTON, Robert William
CUMMINS, James Desmond, B.E., M.SC., PH.D.
CUNDALL, Clifford Miles, B.ENG., PH.D.
DALMON, James
DEAN, Colin, B.SC.
DICKSON, Malcolm Robert, B.SC.(ENG.)
DOUGHTY, Ronald Frederick
DREWERY, Richard, B.SC.
DUCK, Edwin Walter, B.SC.(ENG.)
ELLARD, John Edward, B.SC.
ELLINGHAM, Roy William, B.SC.(ENG.)
ELWOOD, William Norman
EVANS, Desmond John, M.A.
FARQUHARSON-HICKS, Peter Robert
FIELDING, Arthur
FITZGERALD, John Allan, B.SC.
FLETCHER, Lawrence
FLITTER, Peter
FORMAN, Ralph Douglas
FOWELL, Edward Joseph Chalker, B.SC.
FOX, Frederick William, B.SC.
FREEMAN, Roy Basil
GEDDES, John Downie
GILLARD, Jim Henry
GOODE, Francis Norman, M.A.
GRAINGER, Dennis Ivan Alban
GREEN, Anthony John, B.SC.(ENG.)
GRIFFITHS, Llewellyn James, B.SC.(ENG.)
GRIMSHAW, Albert
GUAST, John Thomas Edward
GUY, Frank
HALLIDAY, Donald Albert
HAMILTON, Jerome John, M.SC.(ENG.)
HARVEY, Derrick Herbert Alfred, B.SC.
HAWKINS, Ernest Alfred
HAWKINS, William Richard
HORLICK, Lt. Robert James, B.A., R.N.
HUDSON, Mark Howard Vandermeulen, M.A.
HUNT, Robert Threlfall
HUTCHINSON, Ronald Cecil
JACKSON, Bernard Geoffrey
JAIN, Gyan Chandra
JOHN, Lt.-Cmdr. Edmund Thomas, M.A., R.N.
JOHN, Maldwyn Noel, B.SC.
JONES, David Hopkin
JONES, Glyn Harrison, B.SC.
JOSS, Ian Duncan, B.SC.(ENG.)
KALRA, Surindra Nath, M.S., PH.D.
KANE, Tafel
KINGSBURY, Derek John, B.SC.(ENG.)
LANE, Denis Reginald Henry, B.SC.
LEE, John Henry
LOGIE, Keith Burton, M.A.
LUCKENS, Fielden Spencer Douglas
McCARTEN, Frederick Charles
MACLEAN, Hector Macdonald
McGREGOR, Allan
McINTYRE, John
McKEE, Joseph
MACOWN, Douglas Ross, B.E.
MAUGHAN, Alan
MAYO, Geoffrey, M.ENG.
MEACHIN, Gordon Cyril
MORGAN, Harry James Wade
MORPHEW, Keith Lester, B.SC.(ENG.), M.SC.(ENG.)
NESS, Alexander
NEWCOMBE, Ernest Robert, B.SC.(ENG.)
NICHOLLS, Burwood Peter, B.ENG., PH.D.
NORMAN, Richard George, B.SC.(ENG.)
NUTBOURNE, Lt. Anthony William, M.A., R.N.
O'CIONNAOITH, Eoin Michael Padraig, B.E.
PEARSON, Stanley John
PHILIPPS, John Leslie Edward
PHILLIPS, Howard Charles Francis
PHILLIPS, Ronald
PITCHER, Arnold
RENSHAW, Samuel
RITCHIE, William Malcolm, B.SC.
ROLLO, Peter Eric, B.E.
ROUT, Kenneth
SALMON, Kenneth Arthur Eburn
SALMON, Richard George
SARGEAUNT, Patrick Norman, B.SC.(ENG.)
SCOTT, Peter, B.SC.(ENG.)
SHINE, Anthony Trevor
SILVIE, William, B.SC.
SINGH, Maj. Harbans Mendhi Ratta, B.SC., I.E.M.E.
SMALE, Alan John, B.SC.(ENG.)
SMITH, James David, B.SC.
SMITH, Ralph Cooper, B.SC.(ENG.)
SMITH, Raymond Linton
SMITH, Robert Brian
SMITH, Robert Irving
STERN, Henry Gerald
STURM, Felix B.SC.(ENG.)
TAMIR, Theodor, DIPL.ENG., M.SC.
TEICHER, Ludwik, B.SC.(ENG.)
TODD, Harold
TURNER, Herbert William
TWARDZICKI, Andrzej, B.SC.(ENG.)
UPRIGHT, John Edward
URQUHART-PULLEN, David Ian, B.SC.(ENG.)
VIDLER, Arthur Francis, B.SC.
WAKEFIELD, Jack Richard, B.SC.(ENG.)
WATLER, Robert William
WHITAKER, Stanley
WHITBY, Philip Eric
WIDMAN, Meyer Mandel, B.SC.(ENG.)
WILSON, Thomas William
WOODFORD, Noel Joseph
WRIGHT, Henry Albert, B.SC.(ENG.)
YOUNG, Michael Roy
ZAMBARDINO, Rodolfo Alfredo Giacomo, DOTT.ING.

Student to Associate Member

FINLAY-MAXWELL, Maj. David Campbell
WRIGHT, Roy James Albert

The following elections and transfers approved by the Council are effective from the 9th October 1958

ELECTIONS

Graduates

BAKER Donald Walter
BEAUMONT Douglas William
BISHOP, Eric Roy
BOWLEY, Harry James
COUPE, Jack
CROFT, Lt. Christopher John Lindsay, M.A., R.N.
CUNNINGHAM, Lt. John, B.A., R.N.
DAVIES, Joseph Eifion
DIVALL, Ernest Gordon
DONALDSON, Arthur Reid, B.SC.
DUNN, John, B.SC.(ENG.)
EDWARDS, Brian Alfred
FARR, Leonard Francis
GARDNER, Neil William Christopher B.SC.
GORSE, Ernest Jeffrey
HAMMOND, Donald
HAMMOND, Herbert Henry
HINDLE, Oliver
HORNER, Terence Peter
HOWARD, Peter Eric
LINDLEY, Maurice
McKIBBIN, John Joseph, B.E.
McLAREN, Alexander Cameron
MELLOR, Walter
MILLER, Ronald Leslie
MOORE, Derek
MORTON, Gilbert
NEKRASOV, George, B.E.E.
ROGERS, Phillip Brian
SCHULTZ, Paul, B.E.E.

Elections and Transfers

ELECTIONS

Graduates (contd.)

SINGLETON, Robert Norman
STEPHENSON, John Michael, B.SC.
STRAUSS, Kurt
THOMPSON, Thomas Noel
TOWNSEND, Philip Edward
WALKER, James Murray
WEST, Ronald Terence
WINSCOM, Mervyn Eric Cave
YAPP, Allan Robert Edward

Students

BAYLEY, Colin William
CARROLL, Gerard Richard
CARTER, David John Robert
CLARK, Richard Vaughan
COX, Junior Colin
FLETT, John Robert
GERKEN, Michael John
GERMAN, George David
GRANT, James Ian
GREATREX, Brian Maurice
HARRISON, Kenneth Jeffrey
LE-MARIE, John Richard
LEEDHAM, John William
MASON, Richard Neville
MEREDITH, Roger Alfred
MORRIS, Clive, B.SC.
MORTON, James
PILLAY, Ratnam Kandaswamy, B.E.
SCHOFIELD, Colin David
SINCLAIR, Clive Robert
SPACKMAN, Michael Brian, B.SC.
SUBASINGHE, Don Wimalasiri, B.SC.
TANDAN, Veeresh Kumar, B.SC.
THAKKAR, Rashmikant Madhusudan, B.E.
THAMBAPILLAI, Samuel Gunaseelan, B.SC.
VELUPILLAI, Nagalingam
VICKERS, Brian Anthony
WATSON, Peter
WEBBER, Clarence Henry

TRANSFERS

Student to Graduate

ARMSTRONG, Alan Frederick, B.SC.
BARKER, Edward Byron
BAXTER, Peter, B.ENG.
BLAND, Anthony James, B.SC.
BRADLEY, Peter Anthony, B.SC.
CHISHOLM, Thomas, B.SC.
DAVEY, George Stuart
EDIRISINGHE, Don Francis
FULLER, Peter William Waters, B.SC.TECH.
GODFREY, Ronald McRae
GRIMWOOD, Terence John
HOLME, Reginald Alfred
LIEW, Hoe, B.SC.
NICHOLAS, Clive Harlow, B.SC.
PANNETT, Bryan William John, B.E.
PARKER, John Alexander, B.SC.
PARSONS, Geoffrey Brian, B.SC.
PATEL, Jitendra Chinubhai
PICKWORTH, Cecil Henry John
SMITH, Frank Gerald
SOLARIN, Michael Bolarinwa
TAYLOR, James Rodney, B.SC.TECH.

British Nuclear Energy Conference

DETAILS of four forthcoming meetings of the British Nuclear Energy Conference are given below. Unless otherwise stated, the following particulars hold for them: they take the form of the presentation and discussion of one or more papers; they are held at 5.30 p.m., with tea at 5 p.m.; and tickets of admission are not required.

1958

DECEMBER 4 *Thursday*

Sponsoring society and place of meeting: The Institution of Electrical Engineers, Savoy Place, London W.C.2

A lecture on REVIEW OF WORK TOWARDS NUCLEAR ENERGY FROM CONTROLLED THERMONUCLEAR REACTION

D. W. Fry, M.SC.

DECEMBER 5 *Friday*

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1, **at 6.0 p.m.**

AN EXPERIMENTAL INVESTIGATION INTO THE STRESS DISTRIBUTION IN A BAND-REINFORCED PRESSURE VESSEL

K. G. Mantle, N. Marshall, and P. J. Palmer

DECEMBER 9 *Tuesday*

Sponsoring society and place of meeting: The Institution of Civil Engineers, Great George Street, London S.W.1

THE USE OF RADIOACTIVE ISOTOPES FOR THE INVESTIGATION OF SEWAGE-TREATMENT PLANT

S. G. Burgess and A. F. Green

1959

JANUARY 15 *Thursday*

Sponsoring society and place of meeting: The Institution of Electrical Engineers, Savoy Place, London W.C.2

ELECTRICAL INSTALLATION AT CALDER HALL NUCLEAR POWER STATION

N. J. Mackay and E. Hardwick

Forthcoming Events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and Monographs published individually this month', i.e. about the time when the paper was published as a separate.

November 1958

M **18** *Tuesday* L. A. THOMAS will open a discussion on 'Ferro-Electrics'†

R **19** *Wednesday* J. REDMOND. Lecture on 'Television Recording: A Survey of the Problems and the Methods Currently in Use'†

E **20** *Thursday* K. R. STURLEY, PH.D., B.SC., will open a discussion on 'What is a Cultured Engineer?'* (At 6 p.m., tea at 5.30 p.m.)

R **22** *Saturday* Section Soirée (at the R.A.E., Farnborough)

R **24** *Monday* J. S. SEELEY, B.SC.(ENG.), PH.D., *and* J. BROWN, M.A., PH.D. 'Use of Dispersive Dielectrics in a Beam-Scanning Prism' (Paper 2735 R) *Synopsis:* see p. 620

J. S. SEELEY, B.SC.(ENG.), PH.D. 'Quarter-Wave Matching of Dispersive Materials' (Paper 2736 R) *Synopsis:* see p. 619

A. CARNE *and* J. BROWN, M.A., PH.D. 'Theory of Reflections from the Rodded-Type Artificial Dielectric' (Paper 2742 R) *Synopsis:* see p. 619

S **26** *Wednesday* L. L. ALSTON, B.SC.(ENG.), PH.D., *and* PROF. F. M. BRUCE, M.SC., PH.D. 'Investigations of Power-Follow-Current Phenomena using a Synthetic Power Source' (Paper 2707 S) *Synopsis:* see p. 619

L. L. ALSTON, B.SC.(ENG.), PH.D. 'Impulse Initiation of Arc Discharges' (Paper 2708 S) *Synopsis:* see p. 620

U **27** *Thursday* Symposium of papers on 'Provision of Adequate Electrical Installations in Buildings (see p. 622 and October *Journal*, p. 572)

MED **28** *Friday* WARREN S. McCULLOCH, M.D., *and* W. K. TAYLOR, B.SC., M.SC., PH.D., will open a discussion on problems encountered in the field of neurophysiology (at 6 p.m., tea at 5.30 p.m.)

December 1958

MS **2** *Tuesday* F. MORAN, M.SC. 'Power-System Automatic Frequency-Control Techniques' (Paper 2781 M) *Synopsis:* see p. 619

M. DAVIES, M.SC., PH.D., F. MORAN, M.SC., A.INST.P., *and* J. I. BIRD 'Power/Frequency Characteristics of the British Grid System' (Paper 2790 S) *Synopsis:* see p. 620. **(This is an addition to the programme)**

O **4** *Thursday* (in conjunction with the British Nuclear Energy Conference) D. W. FRY, M.SC. Lecture on 'Review of Work towards Nuclear Energy from Controlled Thermonuclear Reaction'‡

I **8** *Monday* J. E. SHEPHERD will open a discussion on 'What Price for Amenities?'*

R **10** *Wednesday* A. H. MUMFORD, O.B.E., B.SC.(ENG.). Lecture on 'Bridging the Atlantic'†

O **11** *Thursday* C. M. COCK 'The Deltic Locomotive' (Paper 2769 U) (Joint meeting with The Institution of Mechanical Engineers) *Synopsis:* see p. 619

E **12** *Friday* M. BRIDGER will open a discussion on 'Teaching Mathematics to Engineers'* (at 6 p.m., tea at 5.30 p.m.)

R **15** *Monday* C. L. S. GILFORD, M.SC. 'Acoustic Design of Talks Studios and Listening Rooms' (Paper 2676 R) *Synopsis:* June 1958

M **16** *Tuesday* W. J. WEBB, B.SC., and L. A. GINGER will open a discussion on 'Modern Control Techniques on Railways'†

S **17** *Wednesday* E. P. G. THORNTON *and* D. H. BOOTH, B.SC.(ENG.) 'Design and Performance of the Gas-Filled Cable System' (Paper 2754 S) *Synopsis:* see p. 619

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 24TH OCTOBER 1958

	No. of Contributors	£	*s.*	*d.*
£1000 and over	6	6000	0	0
£100 to <£1000	30	6586	3	0
£5 to <£100	866	9180	4	5
£2 to <£5	2084	5730	7	5
Under £2	24192	12643	9	5
		£40140	4	3

APPOINTMENTS AND NOMINATIONS

MEASUREMENT AND CONTROL SECTION COMMITTEE

On the nomination of the National Physical Laboratory, the Council have appointed Mr. G. H. Rayner, B.A., ASSOCIATE MEMBER, to serve on the above Committee.

The Council have also appointed Dr. J. B. Higham, B.SC., ASSOCIATE MEMBER, to serve as their representative on the above Committee.

RADIO AND TELECOMMUNICATION SECTION COMMITTEE

On the nomination of the Army, the Royal Air Force and the Royal Navy, the Council have appointed Col. R. G. Miller, R. SIGNALS, MEMBER, Group-Capt. A. Foden, B.SC.TECH., R.A.F., ASSOCIATE MEMBER, and Capt. R. L. Clode, R.N., ASSOCIATE MEMBER, respectively, to serve on the above Committee.

The Council have also appointed Mr. C. E. Strong, O.B.E., B.A., B.A.I., MEMBER, to serve as their representative on the above Committee.

SUPPLY SECTION COMMITTEE

The Council have appointed Mr. H. V. Pugh, MEMBER, to serve as their representative on the above Committee.

UTILIZATION SECTION COMMITTEE

On the nomination of the Admiralty, the Air Ministry, the Ministry of Labour and National Service, the Ministry of Works, and the War Office, the Council have appointed Mr. P. Smith, B.SC., MEMBER, Mr. H. F. Innocent, MEMBER, Mr. S. J. Emerson, M.ENG., MEMBER, Mr. P. McKearney, O.B.E., MEMBER, and Lt.-Col. R. F. Pratt, B.A., R.E., ASSOCIATE MEMBER, respectively, to serve on the above Committee.

The Council have also appointed Mr. B. L. Metcalf, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee.

OVERSEA REPRESENTATIVES

The Council have appointed Mr. J. H. B. Robins, B.SC.(ENG.), MEMBER, as Oversea Representative of the Council in Ceylon in place of Mr. J. G. Park, MEMBER, who is returning to this country.

The Council have appointed Mr. J. H. Smyth, B.SC., MEMBER, Mr. Shiv Narayan, SC.D., M.SC., B.E., M.A., B.SC., MEMBER, and Mr. J. Meek, B.SC.(ENG.), MEMBER, as Deputy Oversea Representatives in Bombay, Delhi and Madras, respectively.

B.S.I. TECHNICAL COMMITTEE ELE/3—ELECTRIC CABLES

The Council have nominated Mr. H. B. Hughes, B.SC., MEMBER, to serve as their representative on the above Committee in place of Mr. A. Henderson, ASSOCIATE MEMBER.

B.S.I. SUB-COMMITTEE ELE/4/10—CONNECTORS FOR PORTABLE APPLIANCES

The Council have nominated Mr. H. G. F. Lambe, ASSOCIATE MEMBER, to serve as their representative on the above Sub-Committee in place of Mr. J. G. Craven, MEMBER, who has resigned.

B.S.I. TECHNICAL COMMITTEE ELE/25—RAILWAY SIGNALLING NOMENCLATURE AND SYMBOLS

The Council have nominated Mr. D. G. Shipp, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee in place of Major L. H. Peter, M.C., A.F.C., MEMBER, who has resigned.

B.S.I. SUB-COMMITTEE ELE/51/5—MARINE TRANSFORMERS

The Council have nominated Mr. G. J. Tuke, B.SC., ASSOCIATE MEMBER, to serve as their representative on the above new Sub-Committee.

B.S.I. TECHNICAL SUB-COMMITTEE ELE/32/2—RADIO INTERFERENCE FROM IGNITION SYSTEMS. B.S.I. TECHNICAL SUB-COMMITTEE OC/1/3—MARK SUB-COMMITTEE ON RADIO INTERFERENCE. CODE DRAFTING COMMITTEE ON THE ABATEMENT OF RADIO INTERFERENCE FROM IGNITION SYSTEMS (ELCP/14). CODE DRAFTING COMMITTEE ON THE ABATEMENT OF RADIO INTERFERENCE FROM DISCHARGE LIGHTING (ELCP/15). E.R.A. SUB-COMMITTEE ON RADIO INTERFERENCE

The Council have nominated Mr. W. J. Bray, M.SC., MEMBER, to serve as their representative on the above Committees in place of Mr. H. Stanesby, MEMBER, who has resigned.

B.S.I. TECHNICAL COMMITTEE WEE/1—DEFINITIONS AND SYMBOLS FOR WELDING

The Council have nominated Mr. A. E. Villiers, M.A., MEMBER, to serve as their representative on the above Committee.

NATIONAL SOCIETY FOR CLEAN AIR—EXECUTIVE COUNCIL

The Council have nominated Mr. C. T. Melling, C.B.E., M.SC.TECH., MEMBER, to serve as their representative on the above Council for 1958–59.

LOUGHBOROUGH COLLEGE OF TECHNOLOGY, COMMITTEE ON INDUSTRIAL ENGINEERING

The Council have nominated Mr. W. H. Dunkley, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee.

SOUTH-EAST LONDON TECHNICAL COLLEGE, BOARD OF GOVERNORS 1958–61

The Council have nominated Mr. D. P. Sayers, B.SC., MEMBER, to serve as their representative on the above Board.

C.C.I.R. NATIONAL STUDY GROUP NO. 14

The Council have nominated Dr. R. L. Smith-Rose, C.B.E., D.SC., MEMBER, to serve as their representative on the above Study Group in place of Prof. J. Greig, M.SC., PH.D., F.R.S.E., MEMBER, who has resigned.

COUNCIL FOR THE PRESERVATION OF RURAL ENGLAND

The Council have nominated Mr. J. R. Beard, C.B.E., M.SC., HONORARY MEMBER, to serve as their representative on the above Council in place of Mr. T. G. N. Haldane, M.A., MEMBER, who is now residing in Scotland.

KINGSTON TECHNICAL COLLEGE, BOARD OF GOVERNORS 1958–61

The Council have nominated Dr. J. W. T. Walsh, O.B.E., M.A., MEMBER, to serve as their representative on the above Board.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, BOARD OF GOVERNORS

The Council have nominated Sir Willis Jackson, D.SC., DR.SC.TECH., F.R.S., MEMBER, to serve as their representative on the above Board.

LONDON AND HOME COUNTIES REGIONAL ADVISORY COUNCIL FOR HIGHER TECHNOLOGICAL EDUCATION, ELECTRICAL ENGINEERING ADVISORY COMMITTEE 1958–61

The Council have nominated Prof. M. W. Humphrey Davies, M.SC., MEMBER, and Mr. N. C. Stamford, M.SC.TECH., MEMBER, to serve as their representatives on the above Committee.

PAUL INSTRUMENT FUND COMMITTEE

The Council have appointed Mr. T. E. Goldup, C.B.E., PAST-PRESIDENT, to serve as The Institution's representative on the above Committee in place of Dr. W. H. Eccles, F.R.S., PAST-PRESIDENT, who had asked to be relieved of his duties.

THE INSTITUTION SUMMER MEETING

AS previously announced, at the invitation of the Chairman and Committee of the North Midland Centre, a Summer Meeting of The Institution will be held next year in the area of the Centre. Members are now asked to note that the Meeting will take place from Monday evening, 15th June, to Friday evening, 19th June 1959. Further details will be announced in due course.

For 1960, the Council, on behalf of The Institution, have accepted with pleasure an invitation from the Chairman and Committee of the Scottish Centre to hold a Summer Meeting in Scotland that year from Monday, 30th May, to Friday, 3rd June 1960.

CHRISTMAS HOLIDAY LECTURE

AT the invitation of the Council, Dr. E. R. Laithwaite, M.SC., ASSOCIATE MEMBER, will deliver a Christmas Holiday Lecture entitled 'Invention and new machines'. The lecture, which is intended for boys and girls in the fifth and sixth forms, will be given in the Lecture Theatre of The Institution on Wednesday, 31st December 1958, at 3 p.m. and will be repeated at the same time the following afternoon.

Schools in the home counties are being invited to apply for tickets, and a number of tickets will be reserved for members' children; members should apply for these by the 1st December 1958, stating for which afternoon they are required. As accommodation is limited, members are asked not to accompany their children.

The following is a synopsis of the lecture:

The lecture is mostly about research. It is introduced by outlining briefly the history of the induction motor since its invention in 1888. This 'master invention' was followed by a very fertile period of invention and development in rotating machinery. By 1920, essentially new ideas had become rarer, and research in machines had largely given way to development.

In another field of electrical engineering the frontiers of knowledge were being pushed forward much more rapidly. The age of electronics had begun. This process of pushing forward, first on one front, then on another, forms the general pattern of discovery and invention. Already there are signs of a slowing down on the electronics side and a revival in research on machines.

The main part of the lecture is devoted to showing how a whole family of new machines can grow from a single idea and how invention is the result of a combination of shrewd observation and happy accident rather than any deliberate attempt to design a new machine.

Several of the machines described are concerned with motion in a straight line rather than being rotational devices. They include the electromagnetic gun, shuttle-propelling schemes and an electrical aircraft-catapult. The lecture is illustrated by many demonstrations and lantern slides. The possible use of tubular motors in future space-travel provides an interesting talking point.

SUBSCRIPTIONS AND INCOME-TAX RELIEF

THE COMMISSIONERS of Inland Revenue have approved The Institution for the purposes of Section 16, Finance Act 1958; and the whole of the annual subscription paid by a member who qualifies for relief under that Section will be allowable as a deduction from the amount of his emoluments assessable to income tax under Schedule E.

The circumstances relating to claims for income-tax relief are as follows. Commencing with the year ending the 5th April 1959, a member who is an office holder or employee is entitled to a deduction from the amount of his emoluments assessable to income tax under Schedule E of the whole of his annual subscription to The Institution, provided that:

(*a*) the subscription is defrayed out of the emoluments of the office or employment

(*b*) the activities of The Institution so far as they are directed to one or both of these objects:

(i) the advancement or spreading of knowledge (whether generally or among persons belonging to the same or similar professions or occupying the same or similar positions)

(ii) the maintenance or improvement of standards of conduct and competence among members of the profession

are relative to the office or employment, i.e. the performance of the duties of the office or employment is directly affected by the knowledge concerned or involves the exercise of the profession.

A member who is entitled to the relief should apply to his tax office as soon as possible after the 31st October 1958 for form P358 on which to make a claim for adjustment of his 'pay as you earn' coding.

HUNTER MEMORIAL LECTURE

IT was announced in the September *Journal* (p. 524) that Dr. L. G. Brazier, B.SC., MEMBER, would deliver the first Hunter Memorial Lecture on the 8th January 1959. Unfortunately, owing to ill-health, Dr. Brazier has been obliged to withdraw from this commitment. Mr. C. O. Boyse, B.SC.(ENG.), MEMBER, has, however, kindly consented to take his place. Arrangements for the Lecture are, in other respects, as previously announced.

SIR CHARLES PARSONS MEMORIAL LECTURE

THE 1958 Sir Charles Parsons Memorial Lecture will be delivered by Sir John D. Cockcroft, O.M., K.C.B., C.B.E., M.A., D.SC., M.SC.TECH., PH.D., F.R.S., MEMBER, at the Memorial Building, 76 Mark Lane, London, E.C.3, on **Wednesday, 26th November** 1958, at 5.30 p.m. Tea will be available from 4.45 p.m.

The title of the lecture is 'Recent advances in nuclear engineering'. No preprints will be issued. The lecture will be published in the April 1959 issue of the *Journal of the Joint Panel on Nuclear Marine Propulsion.*

Members of The Institution are invited to attend the lecture, which this year is sponsored by the Institute of Marine Engineers.

THE INSTITUTION EXAMINATION

CANDIDATES under the age of 28 who wish to take the Institution Examination should be reminded that they must be Student members at the time of entry for the examination. If they have not submitted proposal form GS they must observe the following dates for the submission of the form:

Date of Examination	*Last date for submitting form GS*	
	Candidates in the British Isles	*Candidates oversea*
April/June	1st November of the preceding year	1st August of the preceding year
October/December	1st May	1st February

CORRESPONDENCE

IN view of the heavy volume of correspondence received daily at the offices of The Institution it is of the greatest assistance when members, in replying to letters received from the Secretary, quote The Institution's reference number. This saves the time of the routing staff and ensures that a letter not only reaches the department concerned without delay but can be immediately linked with the previous correspondence. It is also helpful when members state their class of membership.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

SIR John Hacking, PAST-PRESIDENT, has been appointed the Local Honorary Secretary for Great Britain of the American Institute of Electrical Engineers.

PHYSICAL SOCIETY EXHIBITION

THE 1959 Physical Society Exhibition of Scientific Instruments and Apparatus will be held at the Royal Horticultural Society's Old and New Halls, Westminster, London S.W.1, from Monday, 19th January, to Thursday, 22nd January 1959.

The opening ceremony will be performed by Sir Cyril Hinshelwood, F.R.S., on the 19th January at 11 a.m. Discourses will be given at 5.45 p.m. as follows:

19th 'Physics of controlled thermonuclear fusion' *R. S. Pease*
20th 'Frontiers of space' *R. Page*
21st 'Physical science in the Trans-Antarctic Expedition' *J. G. D. Pratt* (introduced by Sir Vivian E. Fuchs)

Special admission tickets are not needed for the discourses.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

MEMBERS are reminded that notifications of change of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one Local Centre or Sub-Centre to that of another arises as a result of a change of address, the transfer is automatically arranged by headquarters, and the member concerned need not notify also the Honorary Secretary of the Local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested, when notifying a change of address, to give their full initials, their previous address and their class of membership.

SUBSCRIPTIONS AND NATIONAL SERVICE

UNDER a recommendation approved by the Council, the subscription payable by Graduate and Student members during their term of National Service is reduced to 10s. per annum. A member wishing to take advantage of this dispensation should advise the Secretary, giving the date of his call-up.

CONVENTION ON THERMONUCLEAR PROCESSES

ONE of the most significant of recent developments has been the prospect of harnessing thermonuclear power for peaceful purposes. In recognition of the important part which Britain has played in this field, The Institution has arranged a Convention on Thermonuclear Processes, to be held in London on the 29th and 30th April 1959. In view of the rapidity with which the subject is developing, details of the programme have not yet been finalized, but the probable range of topics to be covered is as follows:

Basic physics of thermonuclear processes
Prototype British thermonuclear experiments—Zeta I, Sceptre III, and the Linear Pinch
Constructional features of Zeta I
Design problems in future Zeta-type systems
Possibilities of direct conversion from nuclear to electrical energy.

Reviews of related work in the United States and the Soviet Union will also be included in the programme. Further details may be obtained from the Secretary.

TRANSISTOR CONVENTION

MEMBERS are asked to note that the dates of the International Convention on Transistors and Associated Semiconductor Devices have been changed to the **21st to 27th May 1959.**

B.C.A.C.—A NEW BULLETIN

THE first issue of *B.C.A.C.*, the Bulletin of the British Conference on Automation and Computation, dated September–October 1958, has just been published. Contents of this

20-page issue include a message from Mr. T. E. Goldup, C.B.E., PAST-PRESIDENT, as Chairman of the General Committee of the B.C.A.C.; a note on the formation of the Conference; a short article on the International Federation of Automatic Control; a list of B.C.A.C. members; and a calendar of forthcoming meetings.

Members can obtain copies of the Bulletin (price 1s. post free; or 6s. per year) from The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1.

THE INSTITUTION OF ENGINEERS, AUSTRALIA

CHANGES are announced in the publications of the Institution of Engineers, Australia. In addition to the *Journal*, which will continue in its present format and include papers of general interest as well as joint works or symposia dealing with different aspects of a project, the Institution will, in 1959, publish *Civil Engineering Transactions* and *Electrical and Mechanical Engineering Transactions*.

During 1959 the *Transactions* will be half-yearly; but, as soon as the volume of papers for publication makes it necessary, they will be issued quarterly. They will consist solely of technical papers of particular interest to engineers in the named branches. The cost of the new *Transactions* is (to members of our Institution) 12s. sterling for each separate part of each of the *Transactions*. The cost of each complete title for 1959 is, therefore, 24s. sterling. Editions of the *Transactions* will be limited; orders for 1959 must be received at the offices of the Institution of Engineers, Australia, Science House, Gloucester and Essex Streets, Sydney, N.S.W., Australia, before the 31st December 1958. It will not be possible to fulfil orders received after that date.

TELECOMMUNICATION ENGINEERING

THE second technical convention of the Institution of Telecommunication Engineers will take place in New Delhi on the 27th and 28th December 1958. Subject-matter will include antenna and wave propagation, broadcasting and telephone communication in India, navigational aids, and semiconductors. Details may be obtained from the Honorary Secretary, Institution of Telecommunication Engineers, Post Box No. 481, New Delhi.

AIRCRAFT MATERIALS

NEW DEPARTMENT AT CRANFIELD

THE establishment is announced of a Department of Aircraft Materials at the College of Aeronautics, Cranfield, Bedfordshire. In future, students may elect to take this subject as their main specialization in the post-graduate college diploma course.

The new activity will embrace engineering techniques in the application of materials as well as the basic relevant sciences, particularly physical metallurgy and solid-state physics.

'NEW HORIZONS WITH COMPUTER TECHNOLOGY'

THE 1959 Western Joint Computer Conference will be held from the 3rd to 5th March at the Fairmont Hotel, San Francisco, U.S.A. Joint sponsors of the conference are the Institute of Radio Engineers, the American Institute of Electrical Engineers, and the Association for Computing Machinery.

Emphasis will be on factual papers dealing with the newer applications of computer techniques, such as information retrieval, operation control, pattern analysis, decision making, computer communications and learning concepts, as well as on papers dealing with advances in computer component and systems design.

Inquiries should be addressed to Box 381, Station A, Palo Alto, California, U.S.A.

Contents of the Current Issues of the *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (OCTOBER 1958)

See the Journal for October 1958, p. 567

PART B. RADIO AND ELECTRONIC ENGINEERING (NOVEMBER 1958)

D. KARO, DR.ENG., PH.D., DIPL.ENG. PAPER NO. 2709 R **A Novel, High-Accuracy Circuit for the Measurement of Impedance in the A.F., R.F. and V.H.F. Ranges** *November 1958*

A. E. BARRINGTON, PH.D., B.SC.(ENG.), AND J. R. REES, PH.D. PAPER NO. 2745 R **A Simple 3cm Q-Meter** *November 1958*

J. DAIN, M.A. PAPER NO. 2734 R **Ultra-High-Frequency Power Amplifiers** *November 1958*

C. G. MAYO, M.A., B.SC., AND H. PAGE, M.SC. PAPER NO. 2724 R **Amplitude-Modulated Transmitter Class-C Output Stage** *October 1958*

E. M. DUNSTAN, M.SC., AND M. J. SOMERVILLE, B.SC. PAPER NO. 2705 M **The Reduction of Low-Frequency Noise in Feedback Integrators** *October 1958*

A. C. GORDON-SMITH AND J. A. LANE, M.SC. PAPER NO. 2711 R **Measurements on Gas-Discharge Noise Sources at Centimetre Wavelengths** *October 1958*

P. KNIGHT, B.A. PAPER NO. 2740 R **Methods of Calculating the Horizontal Radiation Patterns of Dipole Arrays Around a Support Mast** *November 1958*

T. HAGFORS, SIV.ING., AND B. LANDMARK, DR.PHIL. PAPER NO. 2743 R **Simultaneous Variation of Amplitude and Phase of Gaussian Noise with Applications to Ionospheric Forward-Scatter Signals** *November 1958*

Discussion on **A Transistor High-Gain Chopper-Type D.C. Amplifier** before the North-Eastern Radio and Measurement Group

PROF. E. BRADSHAW, M.B.E., PH.D., M.SC.TECH., M. WAGSTAFF, M.SC.TECH., AND F. COOKE. PAPER NO. 2425 M, NOVEMBER 1957 **A Train-Performance Computer** *November 1958*

J. F. MEREDITH, B.SC., PH.D., AND E. A. FREEMAN, B.SC. PAPER NO. 2376 M, JULY 1957 **The Simulation of Distributed-Parameter Systems, with Particular Reference to Process-Control Problems** *November 1958*

J. L. DOUCE, M.SC., PH.D., AND J. C. WEST, PH.D., D.SC. PAPER NO. 2393 M, JULY 1957 **A Magnetic-Drum Store for Analogue Computing** *November 1958*

PROF. D. GABOR, DR.ING., F.R.S., P. R. STUART, PH.D., AND P. G. KALMAN, PH.D. PAPER NO. 2661 R, MAY 1958 **A New Cathode-Ray Tube for Monochrome and Colour Television** *November 1958*

D. E. L. SHORTER, B.SC.(ENG.). PAPER NO. 2604 R, APRIL 1958 **A Survey of Performance Criteria and Design Considerations for High-Quality Monitoring Loudspeakers** *August 1958*

Discussion on **The B.B.C. Sound Broadcasting Service on Very High Frequencies** before the South-Western Sub-Centre, the Western Centre, the Southern Centre and the South-East Scotland Sub-Centre

PART C. MONOGRAPHS (SEPTEMBER 1958)

See the Journal for September 1958, p. 519

BULLETIN OF THE SECTIONS

SUPPLY

'Cèud Mile Fàilte'—'a hundred thousand welcomes'

THE Summer Visit to Edinburgh of the Supply Section, attended by a total of 254 members and their ladies, got off to a flying start on the evening of Thursday, 18th September. The Senior Bailie of the city, supported by other bailies and city councillors in full robes of office and guarded by armed halberdiers, received the Chairman of the Section, Prof. M. G. Say, the members and their ladies in the Assembly Rooms. Senior Bailie Brechin said that Edinburgh extended a warm welcome to all, as friends and supporters of Prof. Say, who was so well known in the city for his work at the Heriot-Watt College. He supported this welcome by an invitation to refreshments and dancing in what must be the most famous Assembly Rooms in Scotland.

In a speech of thanks, Prof. Say reminded us we were now in 'Auld Reekie'—although we found it difficult to understand that such a city should be thought of as 'Old Smokey'. During the dancing it was interesting to see some of those from south of the Border mastering the steps of the eightsome reel.

Out and about

Next day, in fine weather, the meeting divided into a large number of small parties and visited such places as the works of the Harland Engineering Co. Ltd.; Bruce Peebles and Co. Ltd.; Ferranti Ltd.; Telegraph Condenser Co. Ltd.; the brewery of Wm. McEwan and Co. Ltd.; and the power stations at Kincardine and St. Fillans. More particularly for the ladies were visits to Donaldson Bros. (Alloa 1937) Ltd., Todd and Duncan Ltd. and the Edinburgh Crystal Glass Co. (it is known that at least one member now owns a do-it-yourself hand-cut crystal goblet of great value to himself!). Much generous hospitality was dispensed by our hosts on these visits, and suitable wee speeches of thanks were made by senior members of the Supply Section Committee on each occasion.

On Friday evening a visit was made to the 'Five-past-eight' show at the King's Theatre, followed by a supper as guests of Scottish Cables Ltd. The whole party enjoyed the Scottish music-hall programme, and later, in a word of thanks to Mr. William Fraser, Managing Director of Scottish Cables Ltd. (whose death on the 11th October 1958 is so much regretted), our Chairman boasted that this successful evening was 'his idea'.

Day of delights

Saturday had been reserved to allow members and their ladies to savour the delights of Edinburgh. It was a lovely day, and Princes Street was thronged with people: the shops took fair toll, and many souvenirs were found. During the day the President and the Secretary joined us, and in the afternoon a tour of the Castle, Royal Mile and other historical parts of the city was arranged. This was enjoyed by all who took part—even though at the end of the afternoon our minds were a confused jumble of names such as Queen Margaret of Queen's Ferry, Robert the Bruce, William Wallace, John Knox, Robbie Burns, Heriot-Watt, John Buchan, Sir Walter Scott, St. Giles, and Arthur's Seat. A pleasant tea, with A. Reyrolle and Co. Ltd. as our hosts, soon refreshed us.

In the evening we were invited to a Dinner-Dance at the North British Hotel by Bruce Peebles and Co. Ltd., with Mr. G. Henderson (Director) in the chair. This was a great success and will be remembered as a highlight of the visit. During the dinner, bright and witty speeches were made by our President, Mr. T. E. Goldup, and Bailie Chalmers Brown ('Benjamin Franklin first met his wife, then discovered electricity'!). In proposing the toast of the Supply Section, the Lord Advocate of Scotland, the Rt. Hon. W. R. Milligan, kept the whole party laughing, and our Chairman maintained the fun in his response of 'pax in bello'. Tribute was paid to Mr. de Villiers, Honorary Secretary of the Scottish Centre, for the energy and effort he had put into making such a success of the meeting.

Dancing continued until midnight, and the fine demonstrations by the Royal Scottish Country Dance Society made this altogether a very happy evening.

Finally, on the Sunday, the meeting divided into two parties to take part in motor-coach tours through the Border country and East Lothian. Ferranti Ltd. made themselves responsible for the wants of the inner man (and woman) during the day, and in fine weather we all enjoyed the scenery of the Walter Scott country. And so, on our return to Edinburgh, the Summer Visit ended. Following an uncertain summer the weather for a few days had been fine and dry, and we all felt a warm feeling inside when we heard the hospitable Scots farewell, 'Greas ort air ais'—'haste ye back'. G. S. B.

UTILIZATION

Annual Dinner-Dance

THE Annual Dinner-Dance of the Utilization Section will be held on the 16th January 1959 at the Café Royal, Regent Street, London W.1. Details and application forms are being sent separately to all members of the Section.

It has been possible this year to secure a Friday booking for the Dinner-Dance, and it is hoped that members will find this arrangement more convenient.

RADIO AND TELECOMMUNICATION

IN the Bulletin of the Sections last month I wrote about the experiment we are making in the programme of meetings in the present session. The introduction of lectures of general interest and of meetings of a definitely specialist character is a bold attempt to adapt our programme to the changing needs of our members. The formal reading of papers at our general meetings is tending to be less effective in these days of ever-increasing specialization, and for many the prime desire is to be given a broad view of important fields outside their own immediate sphere of interest.

This month I wish to deal with another aspect of this general problem that is being actively sponsored by our Section, namely the holding of symposia and conventions on subjects of great topical importance in which rapid advances are being made in many countries. One of their main purposes is to provide a forum where new knowledge may be disclosed and discussed by experts on an international level, while at the same time those who are anxious to learn what is going

on may be brought up to date with the latest developments and their implications.

It will be recalled that the conventions on radiolocation in 1946 and radiocommunication in 1947 arose from the need for the orderly release and distribution of information—much in arrear for reasons of security—on the classical war-time work, and in undertaking the necessary arrangements the Section did a service of immense value to engineers all over the world. It was not until 1952 that the need arose for a further large convention, this time on the British contribution to television. This served to show how the war-time advances in radio technology, which owed so much to British achievements in television in the pre-war years, led to the rapid expansion in this field when the service interrupted by the war was restored.

Major conventions

With the convention arranged by the Section, jointly with the Measurement and Control Section and the Department of Scientific and Industrial Research, on digital-computer techniques, it became clear to the Committee that the increasing pace of activity within the fields of the Section was leading to a need for more conventions.

In October 1956 the Section Committee organized the Convention on Ferrites, and in May of this year an International Convention on Microwave Valves was held in the Institution building, lasting for a period of one week and giving with its parallel sessions opportunity for those attending to present papers and discuss in considerable detail all aspects of the subject-matter of the Convention.

Preparations are already well advanced for an International Convention on Transistors and Associated Semiconductor Devices, which is to be held at Earl's Court from the 21st to 27th May 1959 and for the first time will have associated with it a large exhibition at which organizations concerned in the research, manufacture and application of these devices will have an opportunity to take space and to display exhibits of interest to all those registering for the Convention and to others with a technical interest in this subject.

The need for forward planning of events of this type is well known to the Section Committee, and they are proposing that in May 1960 there should be a convention on the subject of materials and components in radio and electronic engineering, in 1961 on radio and line communication, and in 1962 on television.

Smaller, topical conventions

In addition to these major events it is necessary from time to time to arrange at short notice smaller conventions and symposia dealing with more particular and specialist subjects which are currently of interest. For example, this year a one-day Symposium on Long-Distance Propagation above 30 Mc/s was held in January, followed in March by a two-day Convention on Radio Aids to Aeronautical and Marine Navigation, and in January of next year there will be a two-day Convention on Long-Distance Transmission by Waveguide, a subject which is opening up possibilities of immense importance in many branches of radio and telecommunication.

While the Section Committee are clear that each of these events is designed to fill a need, the view has been expressed by some that too many conventions are now being arranged by The Institution. In the Section Committee's view, the test is whether these events are supported by members of The Institution and others working on the subject to be discussed.

For the symposium and small convention held earlier this year registrations of about 400 and 600 respectively, were received, and 800 people attended the Convention on Microwave Valves. The present indication is that for the Transistor Convention at least 2000 participants can be expected.

The Section Committee would, however, I know, be anxious to point out that in arranging conventions and symposia they are guided to a large extent by the needs of any particular subject as conveyed to them by the experts who serve on the Specialist Panels of the Section and whose duty among other things is to advise the Section Committee on matters of this kind.

Much will depend upon the way in which papers are presented and on the opportunities provided for discussion, and it is here that constructive criticism will be most helpful. I do hope that members who have suggestions to offer that may enable us to make these conventions of the maximum value to all concerned will put them forward for the benefit of the Committee, which exists to foster the interests of our membership as a whole.

G. MILLINGTON

NEWS from the Centres

EAST ANGLIAN SUB-CENTRE

Visit to Cambridge

THE 1957–58 Session terminated with a one-day Summer Visit to Cambridge on the 20th September. During the morning members and their ladies visited various firms and organizations in Cambridgeshire. An informal luncheon was taken in Downing College, and this was followed in the afternoon, in glorious sunshine, by conducted tours of the colleges.

In the evening a dinner party held in Downing College Hall brought to a close a most successful day. Many people had travelled from Norwich and Ipswich, cementing even further the very strong ties that have been made over the past three years since the formation of the Sub-Centre.

One of the principal events of the first half of the 1958–59 Session will be a joint meeting with the Institution of Mechanical Engineers (Eastern Branch) in Cambridge on the 17th November 1958, when Mr. R. Carruthers will give an informal talk on the reactor Zeta. This will coincide with the visit of a Vice-President, Mr. C. T. Melling, to the Sub-Centre.

The main social function of the first half of this session will be the Dinner-Dance for members and their ladies, which will be held in the Dorothy Restaurant, Cambridge, on the 9th January 1959.

University research

The Cambridge Radio and Telecommunication Group on the 30th September commenced the session with an interesting experiment for an ordinary meeting, by arranging for six short papers, on various aspects of electronics, to be read by research engineers of the University. This gave, to a very large audience, a direct insight into various research problems being investigated in the University engineering and science faculties. The subsequent discussion on these papers proved

most stimulating to members both from the University and from industry. The Group Committee are to be congratulated on their enterprise, and they will no doubt be encouraged to arrange further evenings on similar lines. N. H.

SCOTTISH CENTRE

Supply Section visit

TO conclude the 1957–58 Session the Scottish Centre were honoured to welcome the Supply Section on their Summer Visit to Edinburgh on the 18th to 21st September. A record number of members and guests were headed by the Section Chairman, Prof. M. G. Say, and Mrs. Say and included the President and Mrs. Goldup and the Secretary and Mrs. Brasher. An account of the visit appears on p. 632; the Scottish Centre would, however, like to record their appreciation of the very generous hospitality which contributed so largely to the success of the occasion.

Bowler-hatted beginnings

The new session opened in Edinburgh on the 7th October with the introduction of the new Centre Chairman, Mr. R. J. Rennie. It is a noteworthy, and possibly a unique, circumstance that the Chairman of the South-West Scotland Graduate and Student Section is this year Mr. R. M. Rennie, the son of the Centre Chairman. Mr. R. J. Rennie chose as the subject of his Chairman's Address 'Electricity supply in Scotland' and gave a fascinating account of its development from the early days of d.c. dynamos and batteries to the nuclear power station now under construction at Hunterston. Some of the early illustrations showing quaint bowler-hatted gentlemen operating the equipment caused amusement, especially as it turned out that one of them was actually present in the audience. Later pictures and very clearly presented data showed, however, what secure foundations these gentlemen had laid for the subsequent building up of the industry, not only in the populous central area but also in the remote Highlands. E. O. T.

NEWS from Abroad

NEW SOUTH WALES OVERSEA COMMITTEE

Cross-Channel links

A JOINT meeting of the Institution of Engineers, Australia, and the New South Wales members of The Institution was held at Science House, Sydney, on the 23rd September, when Mr. F. J. Lane read a paper entitled 'The proposed cross-Channel interconnection between Great Britain and France: economic and engineering aspects'.

The paper followed closely along the lines of a similar one published in 1954 in the *Proceedings*.* Mr. Lane's explanation of the technical, economic and political considerations which had to be resolved before a compromise solution could be reached, was very interesting indeed.

The discussion was opened by Mr. J. Wilson, who outlined the possibilities for d.c. transmission in Australia. He pointed out that there appeared to be little likelihood of schemes of sufficient magnitude developing on the continent of Australia to warrant adoption of overhead-line d.c. transmission and that the only possibility conceivable here was the transmission of hydro-electric power from Tasmania or New Guinea to the mainland. It appeared that Tasmania would not have sufficient surplus cheap hydro-electric power to warrant the costly installation of a d.c. transmission link to Victoria, and the parts of Australia opposite New Guinea were sparsely settled with no foreseeable load requirements of any magnitude. Moreover, it was likely that, with the declining cost of nuclear power, the economic justification for transmission of large blocks of power from remote sources to load centres would disappear, and the only important remaining reason for large-scale transmission would be the economies inherent in the sharing of spare plant and the connection of systems of differing load characteristics. J. T. R.

* SAYERS, D. P., LABORDE, M. E., and LANE, F. J.: 'The possibilities of a cross-Channel power link between the British and French supply systems', *Proceedings I.E.E.*, Paper 1657, March 1954 (1954, 101, Part I, p. 284)

Mr. T. E. Goldup greeting a Nigerian graduate at a reception for oversea graduates in the Institution building on the 26th September 1958. Nearly 200 graduates from 38 countries attended, including a number of Athlone Fellows and F.B.I. Scholars. The proceedings included the reception by the President and Members of the Council, addresses by the President and by the Chairman of the London Graduate and Student Section, a showing of the film 'The Inquisitive Giant', and a display of exhibits

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